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Report of the Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA)

21 - 26 June 2013

Bilbao, Spain

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Executive summary

The Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA), met at Bilbao (Spain), 21–26 June 2013, chaired by Andrés Uriarte. There were 11 participants from France, Portugal and Spain (one attending on line). The main task was to assess the status and to provide short term predictions for the stocks of Anchovy in Subarea VIII and in Division IXa, for Sardine in Divisions VIIIc and IXa, and in Divisions VIIIab and subarea VII, and for horse mackerel (*T. trachurus*) in Division IXa and Jack Marckerel (*T. pictoratus*) in X (Azores). Most assessments were updated assessments according to the stock annexes, except Jack mackerel in Azores which has a biennial advice.

The Anchovy in Subarea VIII was estimated to be at 56 055 t in May 2013 (within a range 36 220 – 88 925 t), well above Blim, according to the Bayesian modelling of the population. This SSB is perceived to be about 31 % below the 2012 level; Nevertheless the later has been revised upward by 19% as compared with last year assessment. As usual two spring surveys were used as inputs for the Bayesian assessment of the population. After a strong discrepancy of their estimates in 2012, the 2013 estimates of biomass provided by the spring surveys were closer though not coincident (65 909 t the DEPM and 93 854 the acoustic). The decrease in biomass between 2012 and 2013 is related to the relative agreement of both surveys in pointing out that the percentage of age 1 in mass was less than for ages 2 and older, as this imply not a sufficient regeneration of the population in 2013 as to maintain the 2012 biomass. Catch options were provided on the basis of undetermined recruitment in 2014. As in previous years, the WG collected the available data on the fisheries of anchovy in northern areas (Subareas VI, VII and IV), although no assessment is so far required for the anchovy in those regions.

Anchovy in Division IXa, demands separate analysis and advice for the western Iberian Atlantic coasts (i.e. Subdivisions IXa North, Central- North and Central-South) from the southern regions (Algarve and Gulf of Cadiz, i.e. Subdivision IXa South), due to the independent dynamics and genetic differentiation of the populations in these regions. This a data poor stock category for which trend based assessment from surveys is provided. In the western areas catches are generally low, in rare occasion exceeding a thousand tonnes (as in 1995/96). In 2011, after several years of almost null detections, the acoustic PELAGO+PELACUS surveys estimated a Biomass of 27,000 t, in that area, and catches rose up to 3780 t. However in 2013, these surveys estimated a sharp reduction of biomass to rather low normal levels (around 4284 t). This confirms that the outburst episodes of biomass are not sustainable in this North-western region of IXa. In the Subdivision IXa South, where the bulk of the population is usually concentrated and supports a rather stable fishery, the 2013 biomass index from the acoustic PELAGO survey is 49% below the median historic survey results. This estimate was supported by a Spanish recruitment survey in the autumn of 2012which pointed out to a recruitment value below average too. However neither the fishery nor the population indexes (assessed by surveys) show any long trend for the anchovy in IXa south. Exploratory evaluations of current harvest rates in the context of Yield per recruit analysis suggest that current exploitation levels in the IXa seem sustainable. Exploration of length-based reference points also supported this view. There is no information on recruitment that will form the bulk of the catches in the following year.

For the Iberian Sardine, after a gap in survey inputs in 2012, new acoustic surveys in the spring 2013 (PELAGO+PELACUS) allowed an updated analytic assessment of the population. These surveys recorded the lowest historical biomass levels, but at rather similar values as their former estimates of 2011. As such, the assessment based on the Stock Synthesis pointed to a pronounced decline of biomass since 2006 due to the lack of any strong recruitment since 2005. Current biomass of about 192 000 t in 2013, would be around historical minimum, being in 2012 around 64% below the long-term average, while fishing mortality seems to be around the historical average, fluctuating without a clear trend. The stock is expected to decline unless a new strong year class appears. Catch options assuming another low recruitment as in recent years (2008–2012) were provided.

The WG was assessed by the first time the Sardine in Divisions VIIIa,b,d and Subarea VII, by analysing survey trends according to the benchmark carried out in February 2013 (WKPELA). Surveys, restricted to subarea VIII (acoustic –Pelgas- and eggs –Bioman- surveys), show no neat trend in biomass indexes since 2000, though marked fluctuations are recorded. The last big cycle peaked in 2009-2010. Following years were lower but in the middle of the range of biomass for the period 2000-201. Pelgas survey pointed to the highest recruitment in 2013 in subarea VIII. Catch curve analysis on survey and commercial fleets suggest fishing mortality slightly lower than natural mortality, i.e. seemingly sustainable. There is little information from subarea VII: no survey index is available and catches are not monitored for biological sampling, so little can be done in terms of assessing the population and the fishery in this subarea, except assuming trends would be similar to subarea VIII. There is no international TAC for these fisheries. Catch are mainly taken by France and Spain in VIIIa,b,d and by France, Netherlands and United Kingdom in VII.

For the southern Horse mackerel (Division IXa) a new analytical assessment was carried out following the stock annex, with catches up to 2012 and surveys up to 2011 (as the 2012 survey could not take place). The fishery is shared between Portugal and Spain. The estimated SSB shows some decrease since 2007 but with a wide confidence interval (being estimated around 30% below the long term average). The fishing mortality shows a significant decrease in last two years. Recruitment is estimated to be above average in 2011. No precautionary reference points have been defined for this stock. F35%SPR (0.11) is proposed as a proxy for FMSY. Historical fishing mortalities have on average (0.09) been at or below the candidate FMSY (though actual estimates are very uncertain). Catch options were provided under the assumption of historical geometric mean recruitment

For the Jack mackerel (*Trachurus picturatus*) in the waters of the Azores, though the 2012 advice is biennial and valid for 2013 and 2014, the WG continue the collation of data along with some exploratory analysis of that information. The analysis is based on commercial abundance indices from the main fleets, used as an indicator of stock trends. It was noted that catches in 2012 reduced compared to previous years: According to the length and age composition of catches from the purse seine fishery, which target juveniles, this was probably due to a failure of recruits at age 1 in 2012. Although the tuna baitboats do not show a sharp de-crease in cpue as the purse seine fleet for 2012, this could be explained since the bait boats also catch bait offshore when jack mackerel is not available in the coast. As occasional fluctuations of 1 or 2 years have also happened in the past this was not considered to suppose a major warning on the status of the stock or for the fishery.

In addition the WG was asked to report on the advance of the preparation of the benchmarking for Anchovy in Subarea IXa; the WG recommended to delay the benchmarking to 2015, basically due to limited man power and to allow for the new DEPM 2014 survey to be examined by WGACEGGs in Nov2014 and serve as a new input the Benchmark.

Finally the WG proposes in Annex 4 specific actions to be taken to improve the quality and transmission of the data (including improvements in data collection and potential inputs from RACs), as requested to the group.

1 Introduction

1.1 Terms of reference

The **Working Group on Southern Horse Mackerel, Anchovy and Sardine** (WGHANSA), chaired by Andres Uriarte, Spain, met in in Bilbao, Spain, 21–26 June 2013 to:

a) address generic ToRs for Regional and Species Working Groups (see table below);

b) assess the progress on the benchmark preparation of Anchovy in Division IXa.

The assessments were carried out on the basis of the stock annexes during the meeting (not prior to it) and coordinated as indicated in the table below:

Fish Stock	Stock Name	Stock Coord.	Assess. Coord. 1	Assess. Coord. 2	Advice
ane-pore	Anchovy in Division IXa	Spain	Spain	Spain	Update
ane-bisc	Anchovy in Subarea VIII (Bay of Biscay)	Spain	Spain	France	Update
hom-soth	Horse mackerel (*Trachurus trachurus*) in Division IXa (Southern stock)	Portugal	Portugal	Spain	Update
sar-soth	Sardine in Divisions VIIIc and IXa	Portugal	Portugal	Spain	Update
sar-bisc	Sardine in Divisions VIIIabd and subarea VII	France	UK	Spain	Update
jaa-10	Blue jack mackerel (Trachurus picturatus) in the waters of the Azores	Portugal	Portugal	Portugal	Multiyear 2nd year

WGHANSA reported by 2 July 2013 for the attention of ACOM.

1.2 Report structure

Ad hoc and Generic TOR relative to the stocks for which assessment is required are dealt stock by stock in respective chapters of the report: Anchovy VIII (Chapter 3), Anchovy IXa (Chapter 4), Sardine VIIIabd and VII (Chapter 6), Sardine in IXa (Chapter 7) and Southern Horse Mackerel (Chapter 8). Furthermore for Blue jack mackerel (*Trachurus picturatus*) in the waters of the Azores (Chapter 9) which did not required an update assessment, the information of the fishery and CPUEs was updated in order to properly record a marked reduction in catches as a result of likely failure of recruitment.

Specific TOR b (And generic h) on the benchmark preparation of Anchovy in Division IXa was briefly addressed in sections 4.10, asking for a delay of this benchmarking to 2015.

Answer to generic TORs are dealt as follows:

Generic TOR b) Audit the assessments and forecasts carried out for each stock under consideration by the Working Group and write a short report: The Audits are collected in annex 7 (The audit for Jack Mackerel is missing as the assessment was not updated).

Generic TOR c) Propose specific actions to be taken to improve the quality and transmission of the data (including improvements in data collection): Feedback on data issues to the RCMs and PGCCDBS are provided in the table "STOCK DATA PROBLEMS RELEVANT TO DATA COLLECTION" which is annexed to the report (in Annex 4). Further comments are reported in for each stock in their chapters, and a general comment on the quality of catch data is addressed in section 1.4.

In addition at the request of the RACs, there in Annex 4 a Data table with indications of research needs for assessments for DLS. And some indications in section 1.7 Data requirements and needs for future for RACs and DC-MAP input.

Generic TOR d) Propose indicators of stock size (or of changes in stock size) that could be used to decide when an update assessment is required and suggest threshold % (or absolute) changes that the EG thinks should trigger an update assessment on a stock by stock basis. This was dealt on stock by stock basis in the last section of their respective chapters. Though for short living species like anchovy the advice should always be revised annually.

Generic TOR e) Consider target categories for stocks in the medium term as proposed and revise as needed: This is dealt partly in section 1.6 below. But A proper review goes along with the proposal for Data to be collected in future for the DC-MAP for the target category of the stocks for which a table was fulfilled and it is annexed to the report (Annex 4: table "data needs from ICES" in future from the DC-MAP for the target category of the stocks).

Generic TOR j) In the autumn, where appropriate, check for the need to reopen the advice based on the summer survey information and the guidelines in AGCREFA (2008 report): This is dealt on stock by stock basis within last section of their respective chapters.

The generic TORs l.ii (Overview of the sampling activities on a national basis for 2012) is dealt in the following introductory section 1.5.

Generic TOR: m) On basis of the outcomes of WKMSYREF calculate Fmsy for stocks where the information exists but the calculations have not been done yet: A Fmsy is proposed to southern horse mackerel

Finally several annexes contain the remaining issues such as

- Relevant WDs (Annex 4);
- Annexes (Annex 5)
- Timing for Future benchmarks (Annex 6).
- Internal Technical minutes (Audit Reviewers Templates) (Annex 7)

1.3 Comments to the new WG structure and working schedule and workload

Since 2012 the WGHANSA benefits for a total 6 working days (instead of 5), as a result of the stocks added to the WG for assessment (the southern horse mackerel stock (Division IXa), Jack mackerel in Azores Islands and the further request for sardine in VIIIab and VII).

The WG has noticed that there is a continuously increasing amount of demands to the WGs for reporting data issues, availability and transmission issues, data deficiencies, future needs, interactions with RACs etc (Generic TORs c, e, J.ii etc), indicators and criteria for reopening the advice, recommendations, etc which certainly make difficult giving due responses to all these individual requests. On top of this, it was certainly difficult to make the Internal Review Audit of the quality of the stock assessments, and this was only achieved after the WG with little (or none) time for the WG members to properly make the audit and to trigger any amendment in the report. So the group felt that the amount of "extra" work is increasing and becoming unsustainable.

For the former reasons, the amount of days available for the meeting is seen nowadays as a minimum for this Working Group, with the perception that the group is becoming unable of providing satisfactory replies for all the increasing "extra" demands.

1.4 Quality of the fishery input

In the previous WGHANSA in 2012, Spanish Official catches for all the stocks assessed in the group were supplied to ICES on the 21st of June by the Secretaría General de Pesca (SGP), which is the Spanish official national administration responsible for fishery statistics. In all cases, except horse mackerel, the scientific data obtained by the Spanish fisheries research institutes (IEO and AZTI) via their sampling network were used in the assessment, following the procedure applied in previous assessments. For horse mackerel, however the data from the Spanish institutes was not made available to the WG, instead only the Spanish official catches were available. As the members of the WG found inconsistencies between this data and the previous data series (see Section 8.1 for further explanations of past year report), the assessment of horse mackerel was not carried out, in order not to lose consistency with previous ICES assessment.

In 2013 the WG decided to make use of the WG estimates for all stocks by consistency with previous years, but noted that disagreements in the total amount of catches were generally lower than 10%. Discrepancies between WG estimates and Official catches have been put as unallocated catches in WG tables; the differences can originate from the different sources of data information, as for example auction sales or logbooks information.

1.5 Overview of the sampling activities on a national basis for 2012 based on the INTERCATCH database

The Working Group again carried out a brief review of the sampling data and the level of sampling on the commercial fisheries. However this was not made on the basis of InterCatch as this has not been the usual procedure for collecting the national catch data inputting the assessments. The actual use of InterCatch is reflected here below, and further down the level of sampling on National basis by stocks is reported.

Table of Use and Acceptance of InterCatch				
Stock code for each stock of the expert group	InterCatch used as the: 'Only tool' 'In parallel with another tool' 'Partly used' 'Not used'	If InterCatch have not been used what is the reason? Is there a reason why InterCatch cannot be used? Please specify it shortly. For a more detailed description please write it in the 'The use of InterCatch' section.	Discrepancy between output from InterCatch and the so far used tool: Non or insignificant Small and acceptable significant and not acceptable Comparison not made	Acceptance test. InterCatch has been fully tested with at full data set, and the discrepancy between the output from InterCatch and the so far used system is acceptable. ThereforeInterCatch can be used in thefuture.
Example sai-3a46	*Onlytool*	*InterCatchwasused*	*Non orinsignificant*	*Can be used*
ane-bisc	Not used.	Shortage of manpower. Intention of being implemented interseasonally.	Comparison not made	Test notperformedyet.
ane-pore	Not used.	Shortage of manpower. Intention of being implemented interseasonally.	Comparison not made.	No acceptance test has been done so far.
Sar-soth	Used		Comparison not made.	No acceptance test has been done so far.
Sar-north	Not used.	Shortage of manpower. Intention of being implemented interseasonally.	Comparison not made	Test not performed yet.
Hom-south	Notused	Shortage of manpower. Intention of being implemented interseasonally.	Comparison not made.	Test not performed yet.
Jaa-10	Notused	Shortage of manpower. Intention of being implemented interseasonally.	Comparison not made.	Test not performed yet.

The sampling summary by stocks on national basis is the following:

a) Anchovy Other áreas

Country	Official Catch IV	No measured	Official Catch VI	No measured	Official Catch VII	No measured
UK						
France						
Total						

b) Anchovy VIII

Country	Official Catch	% of catch sampled	No. samples	No. measured	No. Aged
Spain	7 896	100%	216	19 049	3 029
France	5 975	100%	25	1 556	2 004
Total	13 871	100%	241	20 605	5 033

c) Anchovy IXa

A corrected version of the sampling activities for 2011 is included, after detection of errors in the numbers provided for Portugal in that year.

2011 data:

Country	Official Catch	% of catch sampled	No. samples	No. measured	No. Aged
Spain	6 758	100%	74	9159	2599
Portugal	3 318	100%	8	419	404 (*)
Total	10 076	100%	76	9365	3003

(*): Anchovy is a group 3 species in the Portuguese sampling plan for DCF. Samples were funded by IPIMAR and age readings were carried out following a IPIMAR-IEO age reading and otolith exchange with 2011 samples (see Soares *et al.*, 2012).

2012 data:

Country	Official Catch	% of catch sampled	No. samples	No. measured	No. Aged
Spain	4 793	100%	48	5924	1467
Portugal	796	100%	14	738	114
Total	5 589	100%	62	6662	1581

d) Sardine North

Country	Official Catch	% of catch sampled	No. samples	No. measured	No. Aged
France	15 952	100%	58	3182	1658
Spain	14 948	100%	127	8580	400
Total					

e) Sardine IXa and VIIIc

Country	Official Catch	% of catch sampled	No. samples	No. measured	No. Aged
Spain	20 620	100%	326	26 002	3 269
Portugal	31 583	100%	114	15 107	3 928
Total	52 203	100%	440	41 109	7 197

f) Southern Horse Mackerel (Division IXa) (A. Murta)

Country	Official Catch	% of catch sampled	No. samples	No.measured	No. Aged
Portugal	15 359	100%	140	8 349	806
Spain	8 373	100%	173	25 336	2 006
Total	23 732	100%	313	33 685	2 812

g) Horse Mackerel (*T. picturatus*) in the waters of Azores (blue Jack Mackerel).

Country	Official Catch	% of catch sampled	No. samples	No.measured	No. Aged
Portugal	1131	100 %	232	12474	133
Total	1131	100%	232	12474	133

1.6 Review of the Generic categorization of stocks of WGHANSA by WKLIFE

(by stock coordinators)

The WG review the categorization made by WKLIFE of the populations being assessed in the WGHANSA as follows:

Fish Stock	Stock Name	Target Category	Comments
ane-pore	Anchovy in Division IXa	3.1	Formerly in 5.2.0, it aims at achieving Category 3 as it has a good monitoring system for catches at length and ages and several direct surveys (acoustics and DEPM)
ane-bisc	Anchovy in Subarea VIII (Bay of Biscay)	1	Good monitoring of catches and direct surveying of the stock (acoustics and DEPM)
hom-soth	Horse mackerel (*Trachurus trachurus*) in Division IXa (Southern stock)	1	Good monitoring of catches and direct surveying of the stock (Bottomo trawl survey)
sar-bisc	Sardine in Divisions VIIIabd and subarea VII	3 in VIIIabd but 4 in VII	Currently in 4 in Subarea VII, as only catches are known in this area (no monitoring of the fishery for length or agees, and no direct surveys) Category 3 in VIIIabd: Good monitoring of catches and direct surveying of the stock in VIIIab, only preliminary assessment was given for orientative purposes.
sar-soth	Sardine in Divisions VIIIc and IXa	1	Good monitoring of catches and direct surveying of the stock
jaa-10**	Jack mackerel (Trachurus picturatus) in the waters of the Azores	3	Currently in 5.2.0 but the Good monitoring of catches and cpue but no direct surveying of the stock.

1.7 Data requirements and needs for future for RACs and DC-MAP input

The Wg has addressed the reporting of data issues, such as availability and transmission issues, data deficiencies, future needs, interactions with RACs etc (Generic TORs c, e, J.ii etc). For it the WG fulfilled the required tables for reporting. All of them are included in Annex 4 of the this report:

- “STOCK DATA PROBLEMS RELEVANT TO DATA COLLECTION”
    - Where the monitoring needs currently relevant to be passed to DC-MAP are listed
- "Data needs from ICES" in future from the DC-MAP for the target category of the stocks.
    - Where the future monitoring needs relevant to be passed to the new DC-MAP are listed according to the desired data quality categorization of the stocks of concern to this WG.
- Data table with indications of research needs for assessments for DLS as requested by RACs
    - Where major weakness or lack of information for future improvement are identified for the stocks of this WG.

2 Anchovy in northern areas.

Both species, sardine and anchovy, exist outside the areas for which assessments are requested by ICES and made. In previous years, some work has been done on the sardine in other areas. Contributions on the occurrence of sardine and anchovy and historical records outside the core areas are useful to build up an understanding of the distribution dynamics of these species as well as potential effect from climate change on spatial expansion of fish stocks.

Anchovy is generally considered to be found in small amounts in other areas, typically associated with river outlets.

The WG reviewed available information on anchovy populations in ICES division IV, VI and VII. Division VII is connected to the Bay of Biscay area where local stock is assessed by this working group. Anchovy populations in ICES division IV (North Sea), VI (West of Scotland) and VII (Celtic Sea and English Channel) are not assessed and not regulated, as those populations have not been considered so far to be locally substantial even if they sometimes represent enough biomass for a small or opportunistic fishery .

2.1 Connectivity between North Sea, Bay of Biscay and Western channel.

In 2010, an ICES Workshop on Anchovy, Sardine and Climate Variability in the North Sea and Adjacent Areas (WKANSARNS) was held to investigate the phenomena of increased catches in anchovy and sardine since the mid-1990s in the North Sea and adjacent areas. The workshop attempted to increase our understanding by considering the phenomenon in terms of the processes controlling the life cycle of anchovy and sardine. It considered the historical context and synthesized across the scientific disciplines of oceanography, climatology, genetics, ecology, biophysical individual-based modeling and analysis of empirical time series.

WKANSARNS concluded that the recent increase of anchovy in the North Sea is probably due to the development of local North Sea populations, rather than a northward movement of Bay of Biscay populations. There has always been anchovy, at a low abundance, in the North Sea (spawning along the Dutch coast, Wadden Sea and estuaries). The expansion of anchovy in the North Sea is thought to be driven by pulses of successful recruitment that are controlled by relatively high summer temperature of sufficient duration followed (or preceded) by favorable winter conditions. There is probably a balance between high enough summer temperature allowing sufficient growth and winter conditions allowing sufficient survival at length. Variability in the length of these periods or in spatial extent where such conditions can be found may have a strong influence on the recruitment success. Whilst this workshop primarily considered driving processes related to temperature, other potential mechanisms, or mechanisms that co-vary with temperature, may be important in the dynamics of North Sea anchovy. The conclusion of the workshop, although preliminary, was that climate-driven changes in water temperature appear to mediate the productivity of anchovy in the North Sea.

On stock definition, the European anchovy shows large amounts of genetic differentiation between populations. An initial analysis has been carried out on the genetic structure of anchovy populations over the whole distributional range of the species by a research group of the genetics laboratory of the University of the Basque Country and Azti-Tecnalia. This study analyses 50 nuclear neutral SNP (Single

Nucleotide polymorphism) markers on 790 individuals covering an extensive regions: North Sea, English Channel, Bay of Biscay, South East Atlantic coast, Canary Islands, South Africa, Alboran, West Mediterranean and East Mediterranean (Adriatic and Aegean seas).

Nei standard (Ds) distance based neighbor-joining tree, pair-wise FST comparisons and the Bayesian approach clustering method suggest that North Sea and English Channel samples are genetically homogenous, exhibiting significant genetic differences with the Bay of Biscay samples. Moreover, Bay of Biscay samples appeared to be genetically more similar to the West Mediterranean samples than to the North sea-English channel samples. These results support that the recent increase of anchovy in the North Sea is likely due to the development of local North Sea populations, rather than a northward movement of Bay of Biscay populations.

In looking for explanations for the recent expansion of anchovy in the North Sea, two main hypothesis arise: sympatry and allopatry. Allopatry could either be due to further adult migration to the north, or increase of larval and juvenile survival into the English Channel and southern North Sea for individuals originating from Biscay spawning. The second hypothesis was tested using a particle tracking model and showed that anchovy eggs spawned in the Bay of Biscay could be transported to the Channel, but no attempt was made to quantify the strength of that potential connectivity. It was also reported that, considering the seasonal shift in the circulation from northward to southward during the anchovy spawning season, and the northward progression of spawning during the season as the temperature increase, retention of eggs in the Bay of Biscay was much more likely compared to transport to the English Channel. The fraction of eggs arriving in the English Channel was low, from ~0% for spawning grounds 1 to 3, to 10% for spawning ground 5 in the north of the Bay (2.11% when averaged over the 5 spawning grounds). 87% of the particles lost from the Bay are entering the Channel, the rest remaining in the Celtic Sea. Results showed that the potential connectivity fraction of the Bay of Biscay to the north of 48°N is only 2%, essentially due to northern spawning in the Bay. Considering the observed spatio-temporal spawning pattern (shift to the north as the season progress), it was concluded that connectivity may be considered as negligible.

In the context of climate change, Bay of Biscay surface temperature has already been observed to increase, which will likely continue. This could advance the spawning season with earlier spawning in the north of the Bay. Under the hypothesis of no other change than temperature increase (e.g. circulation patterns), this would increase the potential for connectivity with the English Channel. From climate change scenarios (temperature increase, wind change) run over the Bay of Biscay, Lett *et al.* (2010) have suggested modification of the circulation with further impact on the dispersal kernel for Bay of Biscay anchovy, among them further distance dispersed under increased stratification.

2.2 Data Exploration from fishery statistics.

Landings and effort data are scarcely available from France and United Kingdom. Length distributions were available in VII from the French observer program at sea (OBSMER).

2.2.1 Catch in divisions IV and VI.

In division IV, landings are very scarce (table 2.2.1) with data available only past 1999 and ranging from 2 kgs to 4 tons (in 2002). Landings in 2010 were 280 kgs. In division

VI, 83 kgs were reported by the French fleets in 2000 and 1875 kgs in 2011. No landings were reported in those divisions in 2012.

2.2.2 Catch in division VII.

In division VII, landings from both French and British fleets have been scarce until 1996 with up to 25t of landed fish (table 2.2.2). The 1997-2012 period has shown a rise of landings up to 244 tons in 2003 followed by a decrease 5 tons over the period 2004-2006 and then strong landings especially in 2009 and 2010 where the strongest landings of the time series were recorded (940 and 1450 tons respectively).

The proportion of France and UK landings in the total catch has been highly variable between years. Over the last three years, French landings have accounted for at least 62% of the total landings of anchovy in that division. It is unknown if the increase of landings in 2009-2010 were a consequence of the expansion of stock of anchovy in the Bay of Biscay. In 2011, only France reported landings (77 tons) for that division. In 2012, landings were 788t for France and 51t for UK.

Most of the French landings occur during the second semester (Q3-Q4) in statistical rectangles 25E4, 25E5 which are adjacent to the VIIIa division (figure 2.2.1). There have been evidences that the Bay of Biscay stock sometimes expand further north the VIIIa division therefore an undefined portion of the catch of anchovy in VII is likely to consist of individuals from the Bay of Biscay stock. A minor portion of the French catch is also made in 26E8 mainly during the summer (quarters 2-3). UK landings are located in the coastal rectangles of north-western part of the Channel (29E4-29E7) and are mainly made during the winter months (quarter 4 and 1).

The landings by the UK fleets are made by ring nets, purse seiners and midwater trawlers. French catches are mainly made by purse seiners (56%) and midwater pair trawlers (44%) (table 2.2.3).

Data from length distribution of catch anchovy are almost non existing. In ICES division VII, 6 fishes were sampled, none in other northern areas in 2012. In previous years, the level of sampling in VII was on some occasion enough to provide comparable length distributions to other areas. All distributions had different modes. Considering the low level of sampling (few stations), it was difficult to give any meaning to those results.

Table 2.2.1: UK and French landings (kg) of anchovy in divisions IV and VI.

	FR-IV	UK-IV	Landings in kg
1983			
1984			
1985			
1986			
1987			
1988			
1989			
1990			
1991			
1992			
1993			
1994			
1995			
1996			
1997			
1998			
1999	1.6		1.6
2000	3.1		3.1
2001			
2002	4029	2	4031
2003	0		0
2004	12.1		12.1
2005			
2006	10.8	0	10.8
2007	50	0	50
2008		2	2
2009	28	127	155
2010	280		280
2011			
2012			

	FR-VI	UK-VI	Landings in kg
1983			
1984			
1985			
1986			
1987			
1988			
1989			
1990			
1991			
1992			
1993			
1994			
1995			
1996			
1997			
1998			
1999			
2000	82.6		82.6
2001			
2002			
2003			
2004			
2005			
2006			
2007			
2008			
2009			
2010			
2011	1875		1875
2012			

Table 2.2.2 UK and French landings (tons) of anchovy in division VII.

	Landings in tons			Portion of landings in	Portion of landings in
	FR-VII	UK-VII	Total	25E4-5 in FR landings	29E4-7 in UK landings
1983					
1984		25.0	25.0		?
1985					
1986	0.0		0.0	?	
1987		5.0	5.0		?
1988		3.9	3.9		?
1989	0.2	16.6	16.8	?	?
1990					
1991		12.0	12.0		?
1992			0.0		
1993	1.7		1.7	?	
1994	0.0		0.0	?	
1995					
1996	0.0			0.0%	
1997	56.0		56.0	84.7%	
1998	0.8	39.0	39.8	0.0%	?
1999	6.0		6.0	0.0%	
2000	51.1	0.0	51.1	71.6%	?
2001	141.0	0.9	141.9	92.3%	?
2002	109.8	0.3	110.1	39.8%	?
2003	220.2	23.8	244.0	50.0%	?
2004	18.2	67.6	85.8	90.9%	?
2005	7.5	7.7	15.2	99.3%	?
2006	5.2	0.2	5.4	61.7%	?
2007	0.3	763.2	763.4	0.0%	?
2008	0.7	175.8	176.5	0.0%	?
2009	585.1	353.5	938.6	85.0%	?
2010	1157.1	319.6	1449.2	84.2%	97.0%
2011	77.0		77.0	52.5%	
2012	788.3	50.9	839.2	91.2%	96.1%

Table 2.2.3 Landings (tons) of anchovy per fleets per year in ICES division VII.

UK Fleets

Gear	2005	2006	2007	2008	2009	2010	2011	2012
MIDWATER TRAWL	5814		619021	10126	98056	10840		34936
RING NET			92560	132294	235788	244935		12220
MIDWATER PAIR TRAWL	1665	200	28103	12600	4286	1100		
PURSE SEINE						47056		
DRIFT NET			5241	17838	1	15613		
UNSPECIFIED OTTER TRAWL			18216	1	270	22		3622
TRIPLE NEPHROPS OTTER					15080			
OTHER OR MIXED POTS				2688				
BOTTOM PAIR TRAWL	245							
BEAM TRAWL				199				
UNSPECIFIED GILL NET			11	27		58		
GILL NET (NOT 52 OR 53)				8		7		
WHELK POTS			1					
Total	**7724**	**200**	**763153**	**175781**	**353481**	**319631**	**0**	**50778**

French Fleets

Gear	2005	2006	2007	2008	2009	2010	2011	2012
PURSE SEINE					392150	517940	39692	445778
MIDWATER PAIR TRAWL		1500			51460	437720	34582	208593
MIDWATER OTTER TRAWL				0.5	78994	68294		
SCOTISH SEINE					53400	33500	137	
BOAT DREDGES				1.7		37200		100
NOT KNOWN					9000	26330		132283
PURSE SEINE 1 BOAT	7415.2	1720					1050	
BOTTOM OTTER TRAWL	54.7	2002	270	19.7	80	4720	601	47
OTTER TWIN TRAWL						2150	21	
GILL NETS				400		1730	936	
TRAMMEL NETS				320				1470
Total	**7469.9**	**5222**	**270**	**741.9**	**585084**	**1129584**	**77019**	**788272**

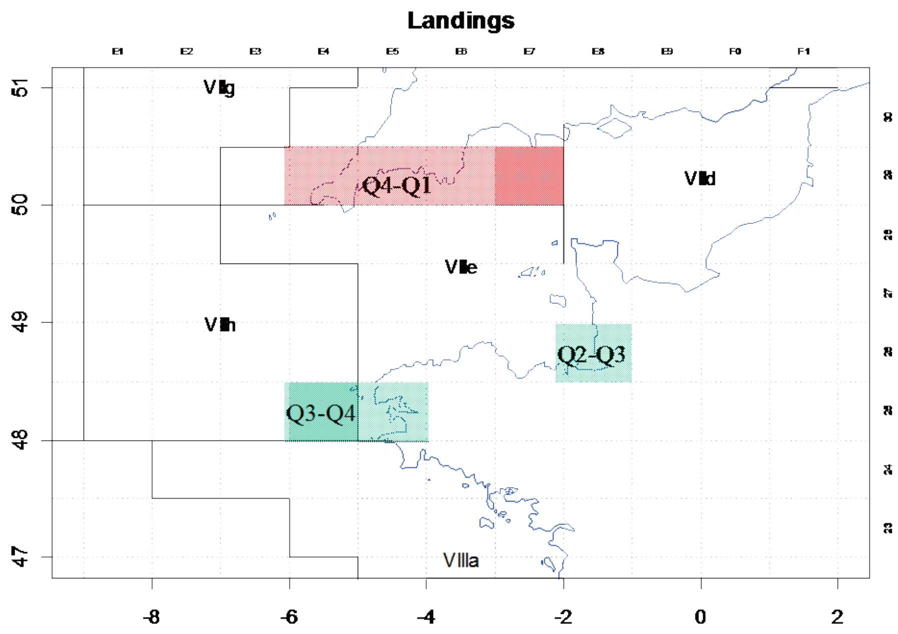


Figure 2.2.1. Map of the statistical rectangles where most of the catches of anchovy occur in ICES division VII for France (Green) and UK (Red).

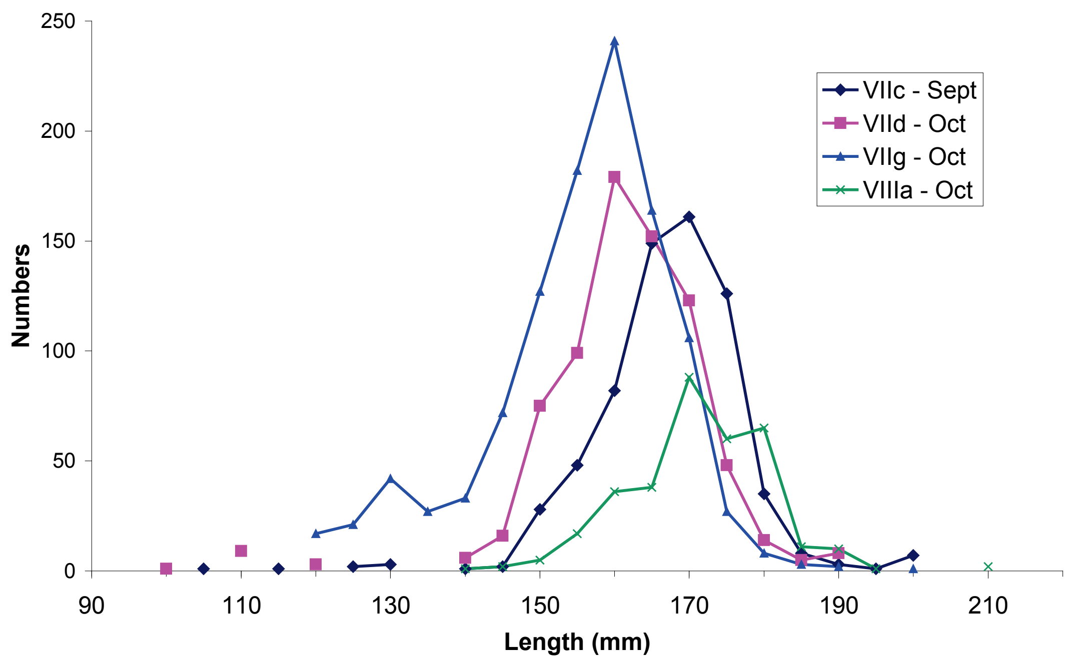


Figure 2.2.2. Length distributions of catch of anchovy in ICES divisionsVIIc, VIId, VIIg and VIIIa.

3 Anchovy in the Bay of Biscay (Subarea VIII)

3.1 ACOM advice for 2012 and 2013

In June 2012, ICES estimated the median SSB at 68 180 t which is above B_{lim} with a 100% probability. On the basis of the precautionary approach ICES advised that assuming an undetermined recruitment scenario for 2013, *"to reduce the risk to less than 5% of the SSB in 2013 falling below B_{lim}, catches in the period 1 July 2012–30 June 2013 should be less than 28 000 t"*.

In July 2012 the Council established the TAC for the fishing season running from 1 July 2012 to 30 June 2013 at 20 700 tonnes (Council Regulation No 694/2012) based on the European Commission long-term management plan proposal. This proposal was presented on 29 July 2009 but it has not been formally accepted yet. It is subject to revision and agreement between the EC, the Council and the Parliament, according to the procedures established in the Lisbon treaty. However, the plan proposal has been used in the last three years (2010-2012) for establishing the TAC for the period between 1st July and 30th June next year, after the period of consecutive fishery closures from July 2005 to December 2009.

The Council Regulation No 694/2012 also established that 90% of the TAC corresponded to Spain and 10% to France. However, due to a bilateral agreement, Spain transferred 10% of the final TAC plus 100 t to France in exchange of access to certain areas for live-bait. This agreement included a fishing ban from December 2012 to February 2013. So, the purse-seine fishery started in March 2013 and the pelagic trawl fishery in June 2013.

In October 2012 the European Commission increased the 2012-2013 fishing quota for anchovy in the Bay of Biscay allocated to France by 636 tonnes (Regulation No 968/2012) based on Regulation (EC) No 847/96 according to which Member States may ask the Commission, before 31 October of the year of application of a fishing quota allocated to them, to withhold a maximum of 10 % of that quota to be transferred to the following year.

In March 2013 the European Commission established deductions from certain fishing quotas allocated to Spain in 2013 and subsequent years on account of overfishing of the mackerel quota in 2009 (Regulation No. 185/2013). In particular, 3696 tonnes will be deduced from the anchovy annual quota from 2016 to 2022 and 180 tonnes in 2023.

3.2 The fishery in 2012

3.2.1 Fishing fleets

For the period July 2006 and December 2009, there was no commercial fishery for anchovy in the Bay of Biscay, due to the closure of the fishery.

Two fleets used to operate on anchovy in the Bay of Biscay before the closure: Spanish purse seines (operating mainly during spring) and the French fleet constituted of purse seiners (the Basque ones operating mainly in spring and the Breton in autumn) and pelagic trawlers (mainly during the second half of the year). A more complete description of the fisheries is made in the stock annex.

The total number of fishing licences for anchovy in Spain increased from 159 in 2012 to 162 in 2013. The distribution of the 2013 fishing licenses by regions was as follows:

PAIS VASCO	CANTABRIA	ASTURIAS	GALICIA	**TOTAL**
58	40	9	55	**162**

For France the number of purse seiners able to catch anchovy in 2012 is around 27. The exact number of vessels is not fixed, due to important movements in this fleet. Most of them are based in Brittany. The number of Basque purse seiners decreases progressively and some of them joined the North of the Bay of Biscay since two years. The real target specie of these vessels is sardine, and anchovy is more opportunistic.

The number of French pelagic trawlers decreased drastically during last years because they were targeting mainly anchovy and tuna. Currently 10 pairs of trawlers (20 vessels) are able to target anchovy.

3.2.2 Catches

In July 2011 a TAC of 29 700 t was established for the period July 2011-June 2012. Overall 3617 t were caught in the second half of 2011 and 8600 t in the first half of 2012. In July 2012 a TAC of 20 700 t was established for the period July 2011-June 2012. In the second half of 2012 around 5800 t were caught. The Spanish catches up to the end of May 2013 were around 7500 t.

Historical catches are presented in Table 3.2.2.1 and Figure 3.2.2.1. The series of monthly catches are shown in Table 3.2.2.2.

The quarterly catches by division in 2012 are given in Table 3.2.2.3. Most of the catches took place in the second quarter (59.3%) corresponding to the major fishing activity of the Spanish fleet. Regarding fishing areas, the catches in the second quarter corresponded to ICES Divisions VIIIb and VIIIc (58 and 42% respectively), whereas the catches in the second semester were mainly taken in ICES Division VIIIb. Some catches occurred at the border between VIIIa and VIIe-h and around 600 tons of anchovy were reported northern than this border, and we assumed these VIIe-h catches in VIIIa, as last year.

3.2.3 Catch numbers at age and length

Catch numbers at age by quarter in 2012 are given in Table 3.2.3.1. Age 2 individuals were predominant in the second quarter, whereas age 1 individuals were the most abundant ones in the third and fourth quarters.

Table 3.2.3.2 records the age composition of the international catches since 1987, on a half-yearly basis. One year old anchovies have dominated in the catches during both halves of most of the years, except in some years with recruitment failure. In 2012, age 2 individuals predominated in the first half and age 1 individuals in the second half.

Catch at length data (by 0.5 cm classes) by quarter are given in Table 3.2.3.3. During the first quarter the catches were very few with a length range between 9 and 17 cm. For the rest of the quarters the modal length was around 15.5 cm.

See the stock annex for methodological issues.

3.2.4 Weights and lengths at age in the catch

The series of mean weight at age in the fishery by half year, from 1987 to 2012, is shown in Table 3.2.4.1. See the stock annex for methodological issues.

3.3 Fishery independent data

3.3.1 DEPM survey 2013 (BIOMAN2013)

All the methodology for the survey and the estimates performance are described in detail in the stock annex - Bay of Biscay Anchovy (Subarea VIII). A detailed report of the survey and results 2013 is attached as **Santos. M *et al.* – WD 2013.**

3.3.1.1 Survey description

The 2013 anchovy DEPM survey was carried out in the Bay of Biscay from 9th to the 28th of May, covering the whole spawning area of the species, following the procedures described in the stock annex- Bay of Biscay Anchovy (Subarea VIII). Two vessels were used at the same time and place: the R/V Ramón Margalef to collect the plankton samples and the pelagic trawler Emma Bardán to collect the adult samples. Sample specifications are given in **Table 3.3.1.1.1**

No anchovy eggs were found in the Cantabrian Coast. The spawning area started at 43º45′N in the French platform and the northern limit was found at 46º15′N. The eggs in the French platform where encountered between Adour and Arcachon and in the area of influence of Le Gironde (**Figure 3.3.1.1.1**).

In relation with the adult samples, most of the hauls consisted of anchovy, horse mackerel, some sardine along the French coast and some mackerel. From 30 pelagic trawl hauls obtained with the research pelagic trawler, 22 had anchovy, and 21 were selected for the analysis. In general, the small individuals were all along the coast and the big ones were offshore. The spatial distribution of the samples and their species composition is showed in **Figure 3.3.1.1.2**; the adults mean weight and mean size in **Figure 3.3.1.1.3**. **Figure 3.3.1.1.4** shows the age composition by haul.

The salinity data obtained during the survey showed clearly the effect of the river discharges of Adour and Gironde and the dispersion of their plumes. This year the mean sea surface salinity (34.72UPS) was at the same levels of last years' (34.77 UPS). The mean sea surface temperature of the survey (14.3ºC) was at the same levels of last years' (14.9ºC). **Figure 3.3.1.1.5** shows the maps of surface salinity and temperature found during the survey.

3.3.1.2 Total daily egg production estimate

The estimates of daily egg production, daily egg mortality rates and total egg production are given in **Table 3.3.1.2 .1** and the mortality curve model used is shown in **Figure 3.3.1.2.1.** Total egg production in 2013 was estimated at 3.24 E+12 with a coefficient of variation of 0.15.

3.3.1.3 Daily fecundity and preliminary index of biomass

In previous years batch fecundity and spawning frequency were not estimated by mid-June and the preliminary SSB estimate for June was based on the average daily fecundity of the historical series (see stock annex- Bay of Biscay Anchovy (Subarea VIII)). This year, as in the last, a first analysis of the batch fecundity was available at this working group and a preliminary daily fecundity was estimated from the sex ratio, the mean weight of females and a preliminary estimate of the batch fecundity. Until the histological analysis of the samples is finished, the spawning frequency was set equal to the historical mean.

Sex ratio (*R*) and mean weight of females (W_f) were directly measured on board from each sample. For batch fecundity (*F*) the hydrated egg method was followed. 104 hydrated females were selected *a visu*, 10 of them were excluded due to the suspected of started the ovulation. By the time being it was not possible to check histologically that these retained females did not start ovulation, so the batch fecundity is considered preliminary (see **Santos. M *et al.* – WD 2013)**

The estimation process of the spawning frequency (*S*) was recently revised (Uriarte *et al*, 2012). This year we included the index of biomass with the average of the new historical series of S and with the traditional historical series of S. This year as in previous ones, the index of biomass adopted was the one with the spawning frequency as the average of the traditional historical series until de new stock annex is approval (see WKPELA 2013). The index of biomass estimate taken the traditional series of S resulted in 65,909 t with a coefficient of variation of 16% and taken the new series of S resulted in 40,797t with a coefficient of variation of 16%. Until the implementation of the new series of S we adopted the index of biomass of 65,909t cv 16% (**Figure 3.3.1.3.1**).

The resulting estimate of the adult parameters and index of biomass with the average of the new historical series and the traditional are given in **Table 3.3.1.3.1a** and **b**

3.3.1.4 Population at age

In order to estimate the numbers at age, 4 strata were defined (**Figure 3.3.1.4.1**). 59% of the anchovy in numbers are individuals of age 1(43%in mass) and 32% of the individuals (in numbers) are of age 2 (43%in mass) (**Table 3.3.1.4.1**). The time series of the age structure of the population is shown in **Figure 3.3.1.4.2**

3.3.2 The Pelgas 13 spring acoustic survey

Acoustic surveys are carried out every year in the Bay of Biscay in spring onboard the French research vessel Thalassa. The objective of PELGAS surveys is to study the abundance and distribution of pelagic fish in the Bay of Biscay. The main target species are anchovy and sardine but they are considered in a multi-specific context and within an ecosystemic approach as they are located in the centre of pelagic ecosystem.

The strategy this year was the identical to previous surveys (2000 to 2012). The protocol for acoustics has been described during WGACEGG in 2009 (*Doray et. Al, 2009*):

- acoustic data were collected along systematic parallel transects perpendicular to the French coast (figure 3.3.2.1.). The length of the ESDU (Elementary Sampling Distance Unit) was 1 mile and the transects were uniformly spaced by 12 nautical miles and cover the continental shelf from 20 m depth to the shelf break (or sometimes more offshore – see figure below).

-acoustic data were only collected during the day because of pelagic fishes behaviour in this area. These species are usually dispersed very close to the surface during the night and so "disappear" in the blind layer of the echo sounder between the surface and 8 m depth.

The calibration method was the same that the one described for the previous years (see WD 2001) and was performed at anchorage in the Douarnenez bay, in the West of Brittany, in medium meteorological conditions at the end of the survey.

Acoustic data were collected by R/V Thalassa along a total amount of 6500 nautical miles from which 1778 nautical miles on one way transect were used for assessment.

A total of 24 432 fishes were measured (including 6260 anchovies and 5910 sardines) and 2633 otoliths were collected for age determination (1249 of anchovy and 1384 of sardine).

A consort survey is routinely organized since 2007 with French pair trawlers during the 18 first days. This approach, in the continuity of last year survey, and the commercial vessels hauls were used for echo identification and biological parameters at the same level than Thalassa ones. A total of 101 hauls were carried out during the assessment coverage including 39 hauls by Thalassa and 62 hauls by commercial vessels. (fig 3.3.2.2.).

As for previous years (except in 2003, see WD-2003), the global area has been split into several strata where coherent communities were observed (species associations) in order to minimise the variability due to the variable mixing of species. Figure 3.3.2.3 shows the strata considered to evaluate biomass of each species. For each strata, energies where converted into biomass by applying catch ratio, length distributions and weighted by abundance of fish in the haul surrounded area (fig 3.3.2.3.).

Biomass indices are gathered in table 3.3.2.1. and 3.3.2.2. No estimate has been provided for mackerel according to the low level of TS and particular behaviour in the Bay of Biscay where it is scattered and mixed with soft plankton echoes. But it might be noticed that mackerel was well present this year, along the slope in the South part of the bay of Biscay and all along the shelf in the Northern part.

The main observation in 2013 is that anchovy was present in important densities at the shelfbreak, near the surface, as abundance in this layer never observed before (Figure 3.3.2.4). These echoes were systematically identified on each transect and revealed most of the time pure anchovy (the biggest individual this year) or at least a large majority of anchovy.

In the Gironde area, we found a configuration more classic (in size and in Sa), with an acoustic energy attributed to anchovy about the average, and far away from the very high energies from 2012. Nevertheless, anchovy was predominant in this area. The most part of the age 1 of anchovy was there, in size class comparable with a “normal” year (all, except 2012 where the fish was much smaller).

Looking at the numbers at age since 2000 (fig 3.3.2.5.), the number of 1 year old anchovies this year seems to be around the average of the serie, but far away from the two previous years level of recruitment. The number of age 2 this year indicates maybe a light overestimate of the last year recruitment. But it must be noticed that the high densities and abundance of anchovy (mainly 2 years old) near the surface, thus in the blind layer of the Thalassa echo-sounders, lead probably to an underestimation of the age classes 2 and 3.

3.3.3 Exploratory comparison between spring indices

A quick exploratory analysis comparing the indices obtained in the DEPM and acoustic surveys was lead this year and presented in two working documents (**Petitgas, P., Huret, M., Doray, M. Coherence between CUFES and Acoustic PELGAS survey indices & Petitgas, P., Duhamel, E., M., Doray, M. Coherence between Egg (BIOMAN) and Acoustic (PELGAS).**

The first step of this study was to compare the following indices: the total daily egg production (Ptot) from PELGAS (based on CUFES data following the method described in Petitgas et al. 2009) vs acoustic biomass from PELGAS (Fig 3.3.3.1), and the total daily egg production (Ptot) from BIOMAN(DEPM survey) vs acoustic biomass from PELGAS (Fig 3.3.3.2).

Assuming that the total daily egg production (Ptot) and the acoustic biomass (B) provide unbiased estimates, we can simply estimate the daily fecundity (DF: # eggs g^{-1} d^{-1}) by the ratio Ptot/B. Note that here, DF is the egg production by gramme of stock (i.e., both females and males). This allows investigating the coherence between the egg and the acoustic survey indices of PELGAS.

Fig 3.3.3.1 shows the relationship between total daily egg production Ptot as estimated from CUFES data in PELGAS and acoustic biomass from PELGAS. The value of the slope was 92.26 eggs g^{-1} and the R-squared of the fitted model was equal to 0.69. The fitted regression model (forced to pass through the origin) is not sensitive to the addition of year 2013. The present analysis shows coherence between CUFES and acoustic. The CUFES index was presented in the last Benchmark Workshop on Pelagic Stocks (WKPELA ICES 2013). The benchmark workshop considered this as a promising approach. However the potential inclusion of this index into future assessments was postponed until the CUFES series is complete (two years are lacking) , and until the series is verified and supported by WGACEGG as a reliable index of anchovy egg production. The whole CUFES series is planned to be available for the next WGACEGG in 2013.

A similar analysis was done using Ptot from BIOMAN survey series of Azti. Ptot as derived using the DEPM from BIOMAN surveys was linearly regressed on B as derived by the PELGAS surveys (Fig. 3.3.3.2.) for the period 2000-2013 except 2001, 2011 and 2012. The value of the slope was 33.88 eggs g^{-1} and the R-squared of the fitted model was equal to 0.68. In 2013, the two estimates are in agreement with the relationship observed in the past as the point-year is close to the regression line.

We have attempted to explain residuals of the fitted model between Ptot from BIOMAN and acoustic biomass from PELGAS with environmental conditions as these may affect DF and/or the relative catchability of the surveys. To characterize environmental conditions we used hydrological indices computed on the CTD profiles that were collected during the PELGAS survey. In each year, CTD casts are performed on a pseudo regular grid covering the Bay of Biscay where spawning occurs predominantly. From the CTD profiles we considered the following indices (detailed in Huret et al., 2013): surface (5m) and bottom temperature, surface and bottom salinity, potential energy deficit to characterize stratification and equivalent fresh water height to characterize river plumes. The residuals were linearly regressed on each of the hydrological indices, one at a time. The regressions selected were those depending on surface temperature and the index of water column stratification and they showed an R-squared > 0.35 and a p-value < 0.1.

The relationships between the standardized residuals and surface temperature (ts) and the index of water column stratification (deficit of potential energy, dep) are shown in Figs. 3.3.3.3. and 3.3.3.4.. In these figures the large residuals for years 2001, 2011 and 2012 are unexplained by the hydrological indices and can thus be attributed to major discrepancies between the egg production estimates from BIOMAN and the biomass estimates from PELGAS . Therefore, these data points were not used in the regression between the residuals and the environmental indices. The correlation between the residuals and the surface temperature might be influenced by the warm 2003 spring. There is a positive correlation between the residuals and the stratification index. The discrepancies in the three years 2001, 2011 and 2012 have stayed unexplained.

3.3.4 Autumn juvenile acoustic survey 2012 (JUVENA 2012)

The JUVENA survey series (Boyra et al. 2013), including the last survey in autumn 2012, was reported and discussed in WGACEGG (ICES, 2012).

In year 2012 the survey was coordinated between AZTI and IEO. AZTI leaded the assessment studies of the JUVENA series and IEO leaded the ecological studies, substantially increasing the planktonic sampling effort and adding new ecological-environmental objectives to the project, as top predator observation or intensive hydrological transects.

The survey JUVENA 2012 took place onboard two pelagic trawlers equipped with scientific acoustic equipment, the R/V Ramón Margalef and the R/V Emma Bardan (**Figure 3.3.4.1**). The survey took place during 35 days in September, sampling 4,000 n.mi. to reach an effective sampling of 2,100 n.mi. that provided a coverage of about 31,500 n.mi.^{2} along the continental shelf and shelf break of the Bay of Biscay, from the 6º40′ W in the Cantabrian area up to 47º 30′ N at the French coast (**Figure 3.3.4.1**). 67 hauls were done during the survey to identify the species detected by the acoustic equipment, 51 of which resulted positive of anchovy (**Figure 3.3.4.2**).

Anchovy was found distributed along two different strata: an external stratum and a coastal stratum. In the external stratum anchovy was located in the uppermost part of the water column forming the typical superficial aggregations of pure juvenile anchovy, mixed in occasions with smaller proportions of juvenile horse mackerel, gelatinous species and krill. In the coastal stratum adult and juveniles were mixed and was detected in schools close to the bottom, mixed also with superior proportions of other species (**Figures 3.3.4.3 and 3.3.4.4**).

The biomass of juveniles estimated for 2012 is 142 083 tonnes (**Table 3.3.4.1**), which represents about the average of the biomass values of the temporal series (**Table 3.3.4.2**).

The relationship between the JUVENA's juvenile abundance index and the recruitment next year (age 1 biomass in January, as estimated by the Bayesian two-stage biomass-based assessment model -BBM) shows that the JUVENA index is a valid indicator of the strength of the incoming recruitment. **Figure 3.3.4.5** compares the times series of the JUVENA anchovy juveniles abundance index with the estimates of biomass at age 1 (median values) from this year assessment (section 3.5), when each of the series is standardised according to their mean and variance. The high estimate of anchovy juveniles in JUVENA 2010 was followed by strong anchovy recruitment at age 1 in 2011. In addition, the low juvenile abundance indices of 2004, 2007 and 2008 are associated with the lowest recruitments estimated by the assessment since 2003. The Spearman rank correlation between the JUVENA series and the assessment estimates of recruitment at age 1 is 0.84, which is statistically significant with p-value=0.004, and the Pearson correlation is 0.96, which is statistically significant with p-value=1.4e-05. This is above the minimums required (around 50%) for recruitment indicators to suppose an improvement in case of using it for the provision of management advice (De Oliveira and Butterworth 2005, De Oliveira et al. 2005). Among several candidate models the best fitting was achieved with a log-linear model (**Figure 3.3.4.6**). The model was significant (p-value=3.02e-05) with R^2=0.89.

3.4 Biological data

3.4.1 Maturity at age

As reported in previous year reports, anchovies are fully mature as soon as they reach their first year of life, in the spring the year after the hatch. See stock annex - Bay of Biscay Anchovy (Subarea VIII) for details.

3.4.2 Natural mortality and weight at age in the stock

Natural mortality is fixed at 1.2, see stock annex - Bay of Biscay Anchovy (Subarea VIII) for further information.

In the Bayesian Biomass Model the parameter *g* describes the annual change in mass of the population by encapsulating the growth in weight (G) and the natural mortality (M) of the population as G-M (0.52-1.2=-0.68).

There are evidences that this parameter *g* is not constant across age groups. An extension of the current assessment method separating the growth in weight and the natural mortality parameters and splitting each of them by age class (Ibaibarriaga *et al.* 2011) suggests larger growth and smaller natural mortality of the age 1 class than the 2+ age class. Previous works by Petitgas *et al.* and Uriarte *et al.* (WDs in WGANSA 2010) also indicated lower natural mortalities than the one currently assumed. The revision of the natural mortality and growth rates by age class was included in the issue list of the benchmark workshop for this stock (WKPELA) that took place in February 2013. However, the inclusion of new values of natural mortality and growth in the assessment of this stock will be subject to the approval of a new stock annex.

3.5 State of the stock

3.5.1 Stock assessment

During the Benchmark Workshop on Pelagic Stocks (WKPELA) that took place in February 2013, the new proposed stock annex was not approved for the Bay of Biscay anchovy population (see section 3.9). Therefore the update assessment of this stock is based on a two-stage biomass-based model (BBM) (Ibaibarriaga *et al*. 2008), which is described in the stock annex that was approved in the Benchmark Workshop on short-lived species (WKSHORT) that took place in August 2009.

The input data entering into the assessment of the anchovy stock consist of:

- total biomass estimated by DEPM and acoustics surveys
- proportion of the biomass at age 1 estimated by the DEPM and acoustic surveys
- total catch during the first period (from 1st January to 15th May)
- total catch during the second period (from 15th May to 31st December)
- catch at age 1 (in mass) during the first period (from 1st January to 15th May).

The historical series of spawning stock biomass (SSB) from the DEPM and acoustic surveys are shown in Figure 3.5.1.1. The trends in biomass from both surveys are similar. In particular, from 2003 to 2010 a parallel trend but with larger biomass estimates from the acoustic surveys is apparent. The largest discrepancy between the SSB estimates from the DEPM and acoustic surveys occurred in 2012. The 2012 acoustic biomass estimate is the largest of their historical series, whereas the 2012 DEPM biomass estimate decreases significantly with respect to 2011. Other discrepancies between DEPM and acoustic surveys (though of smaller magnitude) occurred in 1991, 2000 and 2002. In 2013 both surveys point to intermediate SSB levels, with the acoustic survey providing a larger estimate. The agreement between both surveys is higher when estimating the relative age composition of the population. Figure 3.5.1.2 compares the historical series of the proportion of age 1 biomass of DEPM and acoustic surveys.

Figure 3.5.1.3 shows the historical series of age 1 and total catches in the first period (1st January-15th May) and of the total catches in the second period (15th May-31st December), which are used in BBM. In general catches in the second period are larger than in the first period and most of the catches in the first period correspond to age 1. The absence of catches from 2005 to 2009 correspond to various consecutive fishery closures due to the low level of the population. The fishery was re-opened in March 2010. In 2013 the total catch in the first period was 4960t.

The data used for the assessment are given in Table 3.5.1.1.

Figures 3.5.1.4 and 3.5.1.5 compare prior and posterior distribution of the parameters. Summary statistics (median and 95% probability intervals) of the posterior distributions of recruitment (age 1 in mass at the beginning of the year), SSB (at spawning time which is assumed to be 15th May) and harvest rates (catch/SSB) are shown in Table 3.5.1.2 and Figure 3.5.1.6. The largest probability intervals correspond to the period in which some data are missing. In general recruitment is highly variable from year to year. Recruitment in 2013 is slightly lower than 2012. The median SSB has decreased from last year to average levels in the historical series. The harvest rate in 2012 has increased slightly since 2011. Since the fishery reopening in 2010 the harvest rates are smaller than the levels observed before in 2005. In order to analyse the biomass trends in relative terms, median and 95% posterior probability intervals of the ratio of spawning stock biomass with respect to 1989 spawning stock biomass, in which B_{lim} is based (ICES 2003), are given in Table 3.5.1.2.

Figure 3.5.1.7 shows the posterior distribution of spawning stock biomass in 2013. Current state of the population is summarized in Table 3.5.1.3. Recruitment (age 1 biomass in January) in 2013 is 32 869 tonnes and 95% probability interval between 21 300 and 53 330 tonnes. The estimated level of biomass in 2013 is 56 055 tonnes and the 95% probability interval is 36 220 and 88 925 tonnes. In relative terms the median of the ratio of SSB in 2013 with respect to 1989 biomass (used for defining B_{lim}) is 3.194 (with a 95% interval between 1.998 and 5.057) indicating that current level of the population is well above the biomass in 1989. The biological risk, defined as the probability of SSB in 2013 being below B_{lim} (21 000 tonnes), is 0.

3.5.2 Reliability of the assessment and uncertainty of the estimation

Compared to commonly used assessment methods in ICES, the Bayesian two-stage biomass-based model (BBM) entails changes in both the methodology used for projecting the population forward and establishing catch options and in the terminology in which the assessment and consequent advice is given. Concepts such as fishing mortality or selectivity at age are not used in the model. Alternatively, harvest rates, defined as the ratio between total annual catches and spawning stock biomass, are used. The state of the stock is given in terms of spawning biomass, recruitment is understood as biomass at age 1 at the beginning of the year and management options may be given in terms of catches. Due to the Bayesian framework, all the results are given in stochastic terms and deterministic points estimates are replaced by summary statistics of the posterior distributions of the parameters, such as medians and percentiles.

The observation equations of the model refer just to the age 1 biomass proportion and total biomass indices from the research surveys (DEPM and acoustics). Figure 3.5.2.1 shows the posterior distribution of spawning stock biomass from BBM in comparison to the estimates from the DEPM and acoustic surveys (corrected by their catchability, which is assumed to be 1 for the DEPM and estimated as 1.15 for the acoustic survey). In most of the years the SSB estimates of the surveys taking into account their standard errors fall within the 95% posterior probability intervals from the assessment. In years with big discrepancies between the DEPM and acoustic SSB estimates, like 2000, 2002 and 2012, both estimates are outside this interval. Figure 3.5.2.2 shows the posterior distribution of age 1 proportion in mass from BBM in comparison to the estimates from the DEPM and acoustic surveys. In all the years the age 1 biomass proportion estimates of the surveys are within the 95% probability intervals from the assessment. Pearson residuals of the four indices do not reveal any clear pattern (Figure 3.5.2.3).

Despite the fact that this year the biomass indices from both surveys point out to intermediate levels, the 2013 DEPM and acoustic biomass estimates are both above the final assessed biomass (i.e. they have positive residuals). However the Pearson residuals for biomass and for age 1 biomass proportion in the last years (Figure 3.5.2.3) show that the model estimate for this year is a compromise between all survey estimates (i.e. not only for the DEPM and acoustic SSB estimates, but also for the DEPM and acoustic age 1 proportion estimates all along the time series).

In order to test the sensitivity of the assessment to apparently discrepant SSB indices in the last years, like the high 2011 DEPM biomass index or the high 2012 acoustic biomass index, the assessment was re-run omitting first the 2011 biomass indices from DEPM and acoustic, and then the 2012 biomass indices from DEPM and acoustic. In both cases the age 1 biomass proportions from the DEPM and acoustic surveys were kept as input data since the agreement between both was high. Figure 3.5.2.4 shows the SSB when omitting 2011 and 2012 SSB indices in comparison with the updated assessment run this year. Without the 2011 biomass indices (DEPM and acoustics) the biomass estimates decrease by about 3000t in the last 4 years in comparison with the update assessment. On the contrary without the 2012 biomass indices (DEPM and acoustics) the biomass estimates increase by about 3000t in the last 3 years in comparison with the update assessment. In any case, the trends in biomass are almost the same and only the biomass levels in the last years change slightly. Other parameters that are affected (to a minor extent) by the inclusion or not of these points are the catchabilities of the surveys and the precision of the biomass observation equations. Therefore, the WG considers that the main reason for assessment model results to indicate a drop in the spawning biomass in 2013 compared to 2012 is the consistent low percentages at age 1 in biomass from the two surveys. The lower percentage of age 1 compared to age 2 to the final biomass estimate is an indicator of a drop in the biomass and this is probably guiding the final SSB estimate in 2013. The abundance index of anchovy juveniles in 2012 (from JUVENA) pointed towards a drop in the recruitment level at age 1 expected in 2013 compared to those in 2012, and hence in the same direction of the outcome from the assessment (see section 3.9). This gives some independent support to the latest tendency shown by the assessment.

The DEPM estimates provided in June are preliminary, given that the adult samples have not been fully processed. This year, as in last year, all the adult parameters, except the spawning frequency, are estimated (see section 3.3.1 and WD Santos et al. 2013). The final estimates will be made available to WGACEGG in November. As a result the stock assessment has to be considered also as preliminary.

In this model catch data are accounted for in the development of the dynamics of the population. Therefore, it is necessary to continue the collection of total landings and catch at age data.

The assessment is scaled by the assumption of absolute catchability of DEPM surveys. The current perception of the population in relative terms (SSB/SSB1989) is insensitive to the use of the DEPM survey as absolute or relative. It is the absolute level of the assessment results (i.e. the mass in tonnes corresponding to the spawning population) that is dependent on the catchability assumptions of the assessment. This implies that the absolute level of the harvest rate, defined as the ratio between total annual catches and spawning stock biomass, is also dependent on the catchability assumption. It therefore must be emphasized and admitted explicitly that the assessment should always be examined in relative terms, exploring the trends in biomasses or harvest rates even under the assumption of DEPM being an absolute abundance estimate.

Other important assumptions of the current assessment are that the natural mortality and growth rates are constant across ages and from year to year and that the catchability of the surveys is constant across ages. This may imply some artificial reduction of the posterior probabilities profiles of the outputs from the assessment. In addition, the value assumed for g (natural mortality and growth) could be another source of uncertainty in the current assessment. The 5 years fishery closure has allowed new studies on the natural mortality (see section 3.4.2) indicating that it might be different by age and lower than the currently assumed rate. This was considered in WKPELA (ICES 2013), but does not apply to the current stock annex based on WKSHORT (ICES 2009).

The DEPM series of biomass was revised due to changes in the procedures for spawning frequency estimates (WGACEGG ICES 2012, WKPELA ICES 2013). Its inclusion was considered in WKPELA (ICES 2013) but cannot be adopted until the new stock annex is approved.

The methodology is the same as described in Ibaibarriaga *et al*. (2008) and in the stock annex. The only change is that, as in the last year, longer runs (500 000 draws) with longer burn-in period (100 000 draws) and higher thinning (1 out of 40 draws was kept) were conducted to ensure convergence.

Figure 3.5.2.5 compares the SSB estimates from the assessment conducted in WGHANSA 2012 and the updated assessments. The results are almost identical, with a small revision upwards of the final SSB estimates in the last three years. This upwards correction has been observed in previously conducted retrospective analysis (see for instance the WD Ibaibarriaga et al. (2013) to WKPELA ICES 2013).

3.6 Short Term Prediction

3.6.1 Recruitment prediction

The prediction of the population for next year in order to explore catch options requires predicting recruitment entering the population.

At the time of the Working Group meeting, there are no indications about next incoming recruitment. Since the population seems to have recovered from the period of low levels of recruitment (2002-2009), the WG decided to make the projections under an undetermined recruitment scenario, where all the past recruitments are equally likely. The resulting recruitment distribution, with median at 45 255 t, is shown in Figure 3.6.1.1.

The construction of alternative recruitment scenarios based on the recruitment indices from juvenile acoustic surveys and from environmental variables is discussed in sections 3.7.

3.6.2 Method

The method for predicting the population is based on the Bayesian two-stage biomass-based model and it is described in detail in the stock annex. This method was approved in the Benchmark Workshop on Short-lived species (WKSHORT) that took place in August 2009.

3.6.3 Results

Starting from the posterior distribution of SSB in 2013 the population was projected one year forward under the undetermined recruitment scenario.

Under the assumption that this year the percentage of the catch taken until mid May with respect to the catch taken during the first semester will be equal to the historical average (0.579), the catches from the 15th May to the end of June in 2013 were assumed to be equal to 3 606 t. Total allowable catch between 1st July 2013 and 30th June 2014 were explored from 0 (fishery closure) to 40 000 tonnes with a step of 1 000 tonnes. In addition, the effect of the percentage of those total allowable catches corresponding to the second half of 2013 was also studied by considering percentages from 0 to 100% with a step of 5%. The timing within the year in which the catches in the second half of 2013 and the first half of 2014 were assumed to occur were computed as the average time points from the historical series from 1987 to 2012 excluding the years 2005-2009 in which the fishery was closed during all or some part of the year. Similarly, the percentage of catches in the first half of 2014 taken before the 15th May, when SSB is estimated, was assumed to be equal to the average from the historical series between 1987 and 2012 excluding the years 2005-2009 (57.9%). Probability of SSB in 2014 being below B_{lim} was derived for each of the catch options and for the percentages of catch corresponding to the second half of 2013.

Figure 3.6.3.1 shows the distribution of SSB in 2014 in the absence of fishing from 1st July 2013 to 15th May 2014. Under this condition the probability that SSB in 2013 is below B_{lim} is 0.

The probability of SSB in 2014 being below B_{lim} is given in Figure 3.6.3.2 (upper panel) and Table 3.6.3.1. The probability of SSB being below B_{lim} is above 0.05 for catches larger than 20 000t. The probability of falling below B_{lim} is almost insensitive to the allocation into semesters, but it increases slightly for larger percentages of the TAC taken in the second semester of 2013. The corresponding predicted median SSB values in 2014 are shown in Table 3.6.3.2. According to the harvest control rule included in the long term management plan proposal launched by the European Commission on 29 July 2009, the TAC for the fishing season running from 1 July 2013 to 30 June 2014 should be established at 17 100 t. The corresponding probability of SSB in 2014 being below B_{lim} under different allocation into semesters is shown in Figure 3.6.3.2 (lower panel).

3.7 Reference points and management considerations

3.7.1 Reference points

The precautionary reference points and their definitions are found in the Stock annex. Precautionary reference points were not revised by the WG this year.

The precautionary reference points were set according to stock estimates with ICA and within the standard framework related to deterministic stock assessments. For the anchovy, a Bayesian assessment is now well established, and the reference points may need to be revisited within that conceptual framework.

Because the assessment provides the probability distributions for the SSB, the rationale to maintain a B_{pa} under the assumption that being at B_{pa} would imply a low risk to B_{lim} becomes irrelevant. Furthermore, under the MSY framework for advice, B_{pa} is in principle redundant, and will be substituted by a $B_{trigger}$ below which fishing mortality should be reduced below F_{MSY}.

B_{lim} is defined by ICES as the SSB below which recruitment becomes impaired (ICES 2003). For stocks with a clear plateau in the S/R scatter plot (a wide dynamic range of SSB, but no evidence that recruitment is impaired) it was recommended to identify B_{loss} as a candidate value of B_{lim}, below which the dynamics of the stock is unknown. When defining the reference points for anchovy -in 2003 -, it was considered that "the dynamic range in SSB and R has been relatively large, but there is no clear signal in the S/R relationship. Furthermore, the assessment time-series is relatively short. B_{loss} should be maintained as B_{lim}." Hence B_{lim} was set equal to B_{loss} = 21 000 t, which was the lowest spawning biomass (SSB) in the ICA 2003 assessment (corresponding to year 1989).

The B_{lim} is set with reference to a particular year where a normal recruitment occurred at the historical low SSB. The assessment provides a probability distribution of SSB_{1989} which is updated every year. An alternative would therefore be to consider the current SSB relative to SSB_{1989} in probabilistic terms. This is now done routinely by considering the distribution of the ratio SSB_y/SSB_{1989}. The median and 95% probability intervals of such ratio for the current assessment are presented in **Table 3.5.1.2** and the distribution for 2013 indicates that there is a 0 probability of being below B_{lim} (21 000 t).

3.7.2 MSY and the precautionary approach

According to the recent advisory practice (ICES advice 2010, Book1, Section 1.2 General context of ICES advice), the ICES MSY approach for short-lived stocks is aimed at achieving a target escapement (BMSY-escapement, the amount of biomass left to spawn), which is more robust against low SSB and recruitment failure than a fishing mortality approach.

This applies to the Bay of Biscay anchovy. Hence, defining an F_{MSY} is irrelevant, and advice aiming at MSY is equivalent to the precautionary approach advice.

3.7.3 Short term advice

Providing a risk adverse advice according to the precautionary approach has two separate aspects, and the anchovy requires special considerations on both.

1. For *tactical advice* in the short term perspective, where the risk to B_{lim} is calculated as part of the short term prediction, this translates into

recommending a TAC which implies a low risk of leading below B_{lim}, for selected scenario(s) of recruitment.

2. When *evaluating a harvest control rule* or management strategy, one will consider a plausible range of future natural variations (recruitment, weight, maturity) and require that the rule should imply a low probability that the modelled 'real' stock falls into an unwanted state of reduced productivity, when the rule is practised based on uncertain observations of the state of the stock. Low probability is usually interpreted as SSB < B_{lim} at least once over a time period in less than 5% of the cases (ICES 2008).

With respect to tactical advice on the anchovy in the absence of a harvest rule, the Bayesian assessment model provide estimates of the uncertainty which are expressed as posterior distributions of the interest parameters. The posterior distributions express the uncertainty of the results given the uncertainty of the data and the prior assumptions, and presumably represent more realistic estimates of the uncertainty than the assumptions underlying the distance between B_{lim} and B_{pa} in the common deterministic framework. The distribution, and in particular the outer percentiles might be sensitive to the "a priori" assumptions. The distribution of the predicted biomass after the TAC is taken is also broadened by the uncertainty in future recruitments.

In June, at the time when the short term prediction is made, there is nothing to indicate the strength of the incoming year class. Recently there has been a period (2002-2009) with successive recruitment failures, from which the population seems to have recovered. Therefore an undetermined scenario was assumed based on a mixture distribution of all the past recruitments.

The JUVENA survey now has been conducted for 10 years (2003-2012). Last year WGHANSA had a specific ToR regarding the usefulness of the JUVENA surveys and the most appropriate time-frame for its potential use for management advice. ICES in the advice stated that *the JUVENA acoustic index of juveniles is a valid indicator of the strength of the incoming recruitment and hence useful improving the forecast of the population and potentially its assessment. The use of this index as a tool to forecast the population in next year, should serve to either review the TAC set currently from July to June, or to generate an advice for a TAC going from January to December based on the autumn acoustic survey.* The validity of the JUVENA juvenile abundance index as an indicator or next year recruitment is confirmed in section 3.3.4. The best use of this index was discussed in the Benchmark Workshop on Pelagic Stocks (WKPELA) that took place in February 2013. WKPELA proposed to include the JUVENA index in the assessment with the possibility of updating the assessment in December once the latest index is available. This cannot be applied until the new stock annex is fully approved. However, following the methodology described in the current stock annex, the short term predictions can be updated in November-December with a new recruitment scenario based on the latest JUVENA index (see WGHANSA ICES 2012 and the WD Ibaibarriaga et al. to WKPELA ICES 2013).

To base the advice routinely on the 5-percentile of the SSB distribution relative to B_{lim} may not be adequate both because the distribution represents a broader range of uncertainty, because of the additional recruitment uncertainty and because the 5 - percentile is poorly estimated and highly sensitive to assumptions. Uncritical use of the 5-percentile as a criterion may lead to an advice to close the fishery far more often than necessary if the distribution is broad enough. For small pelagics, which are inherently highly variable, the 5% of risk may be unnecessarily high. Instead of looking for a reference risk, the increased risk due to fishing should be evaluated.

3.7.4 Management plans

A draft management plan was proposed by the EC in 2009 in cooperation between science (STECF) and stakeholders (South Western Waters RAC). This plan has not yet been formally adopted by the EU, and it has not been presented to ICES for evaluation. However, the plan has been used in the last three years (2010-2012) for establishing the TAC for the period between 1st July and 30th June. The plan is based on a constant harvest rate (30%), and sets a TAC as a percentage of the point estimate of the SSB as assessed at the start of the TAC period which runs from 1st July to 30th June, but with an upper bound on the TAC (of 33 000 t), and with a minimum TAC level (of 7 000 t) applicable at SSB estimates between 24 000 tonnes and 33 000 tonnes. It is understood that the TAC this year will again be set according to this draft plan.

The draft plan has a clause to revise it within 3 years after it has been accepted, and WGHANSA assumes that future revisions will take recent scientific developments into account. In February 2013 this stock was benchmarked in the Benchmark Workshop on Pelagic Stocks (WKPELA). No new stock annex has been approved for this stock (see section 3.8). However, the list of issues discussed during WKPELA 2013 might imply significant changes in the assessment and projection methods. Given that the current long-term management plan proposal for the stock is based in the methods described in the stock annex approved by WKSHORT 2009, the SSB estimates obtained by a new assessment could not be used to apply the harvest control rule within the LTMP proposal. Therefore, when a new stock annex is available for anchovy in the Bay of Biscay, the draft plan will need to be extended and adapted to the new assumptions and developments. This implies a considerable amount of work. The WGHANSA has no views on how this work should be organized, but notes that ICES on some occasions has assisted in such processes by providing scientific insight on opportunities and limitations, in a dialogue process with managers and stakeholders, as outlined by SGMAS (ICES 2008) and practised for a number of stocks.

Bay of Biscay anchovy is one of the few stocks considered by ICES where uncertainties are considered explicitly in the assessment. Hence, there is information available not only on the point estimates of biomasses, but also on their distributions. This opens for opportunities to properly evaluate risks in terms of the combination of likelihood and costs, which may give a firmer basis for rational decisions about management plans. This would facilitate managers finding the probabilities of an unacceptable low stock abundance which imply the best counterbalance between the biological, economic and social concerns.

3.7.5 Species interaction effects and ecosystem drivers

Anchovy is a prey species for other pelagic and demersal species, and also for cetaceans and birds. Recruitment depends strongly on environmental factors, and several recruitment predictions have been proposed in the past based on environmental variables. Approaches like the one presented in Fernandes *et al* (2010) look promising, but its prediction capacity is still being tested.

3.7.6 Ecosystem effects of fisheries

These effects are not quantified.

3.8 Pending issues from WKPELA 2013

The Benchmark Workshop on Pelagic stocks (WKPELA) took place in February 2013 to determine and review the appropriate stock assessment method of the Bay of Biscay anchovy and other two pelagic stocks. The final assessment was based on the CBBM model (Ibaibarriaga et al. 2011) with changes to settings of natural mortality rates. In addition, the DEPM SSB estimate was considered as a relative index (incorporating the latest revision of the DEPM estimates reported to WGACEGG 2012), and the JUVENA juvenile acoustic biomass was included as an index of recruitment next year. However WKPELA was unable to decide on the final setting regarding the variances of the observation equations. In the option presented in the stock annex the precision of the observation equations of biomass from the DEPM and acoustic surveys were taken as fixed (not estimated). After the meeting another option was tested where the variances of SSB observation equations from the surveys were split into partly fixed and estimated variances. This alternative option was added as an annex to the WKPELA report.

The inclusion of the JUVENA juvenile abundance index in the observation equations of the CBBM assessment model was based on a linear relationship between this index and next year recruitment (age 1 biomass at the beginning of the year). This is similar to the observation equation of the DEPM and acoustic biomass indices. The hyper-parameters of the prior distribution of the catchability of the JUVENA survey where taken equal to those of the prior distributions of the catchability of the DEPM and acoustic surveys. The sensitivity of the results to the observation equation relating the JUVENA juvenile abundance index and recruitment next year (linear or power) and the hyper-parameters of the prior distribution of the parameters defining this relationship were not studied in detail due to the lack of time, and were included in the list of issues to be further studied (WKPELA ICES 2013).

All these pending issues were studied in the working document WD 2013 Ibaibarriaga and Uriarte. The main results show that the prior distribution considered in WKPELA for the catchability of the JUVENA index might be too restrictive. In addition, the power model resulted to be more adequate than the linear model for the observation equation relating the JUVENA juvenile abundance index and recruitment next year. Regarding the last pending issue on the final setting of the variances of the observation equations, the working document presents a retrospective analysis of the assessments conducted in December under the various variance settings in order to study further the assessment and projection properties. However no final proposal on the best variance settings was done. During WGHANSA, a new variance setting derived as a compromise between the previous settings was studied. The variances of SSB observation equations from the surveys were split as the sum of observation and residual variances (as in Annex 3), but without estimating them (as in the proposed Stock Annex).

After the examination of the all the results produced during WKPELA 2013 and WGHANSA 2013, the Working Group concludes that (1) the power catchability model of JUVENA along with the priors proposed in the WD2013 Ibaibarriaga et al WGHANSA is preferred over the linear catchability model as it results in more precise estimates of the incoming recruitments (2) the setting of the observation variance for the spring surveys, which certainly result in different Pearson residuals of the fitting to the surveys and in different retrospective patterns, might not imply major differences in the forecasting capabilities of the models of the population in next years. The WG considers however the convenience of extending the analysis of retrospective patterns in the assessments and forecasting capabilities a year ahead by comparison with the assessment that would result this year in June. After examination of this analysis, the WG would be in the position of taking the decision of whether adopting one of the two stock assessment options outlined in WKPELA (with duly justified minor variants) or finally asking for a new benchmark to solve the pending technical issues. This final analysis and decision will take place by correspondence before 12 July and the decision will be submitted directly to ACOM by the chair of the WGHANSA.

3.9 Indicators and thresholds to trigger new advice

ACOM is the process of streamlining the advisory process from assessment EGs to the final advice in order to reduce the workload for the expert community. In the future, the idea is that the assessment (and possibly the advice) would not be updated unless one (or more) previously defined indicator (survey or other indices) meets a predefined threshold. This way, working groups would check indicators and only update the assessment and /or the forecast if the indicator shows a significant change from the previous year.

Under this circumstances, this year WGHANSA has a term of reference (ToR d) asking to *propose potential indicators of stock size (or changes in stock size) including threshold % (or absolute) changes that may trigger an update assessment*.

Anchovy in the Bay of Biscay is a short-lived pelagic species. Therefore the population level every year depends strongly on the abundance of the incoming year class which is highly variable and largely dependent on environmental factors. In addition, natural mortality is usually high and very variable from year to year. These characteristics make the assessment and management of small pelagic fish difficult (Barange et al. 2009). The most effective management strategies are based on closely monitoring the population by fishery-independent research surveys that can be used either for assessment purposes or as information directly used for management decision making either in the short or in the long term.

For the Bay of Biscay anchovy the two spring surveys (DEPM and acoustics) provide information on the stock size and its age structure every year, including the strength of new cohort recruited to the population (age 1 individuals). The WG considers that the best indicator on stock size for this stock is the biomass estimate from the assessment and emphasizes the need to conduct the spring surveys and update the assessment in June every year.

However, the major difficulty when providing management advice in June is the absence of information on next year recruitment, which will form the major part of the population next year. Currently the JUVENA surveys (available since 2003) provide a reliable index of next year incoming year class that is available by mid-November (see section 3.3.3 and 3.7). This opens the possibility to re-open the advice delivered in July based on the latest JUVENA index as mentioned in the last years' ICES advice. Currently ICES advice in July is based on the precautionary approach. Under an undetermined recruitment scenario the short term predictions allow to evaluate the level of risk (probability of SSB being below B_{lim}) associated to different catch options. The advice then indicates the maximum allowable level of catches to keep next year biomass within safe biological levels (i.e. with risk lower than 0.0 5). These short term predictions can be updated based on a new recruitment scenario based on the latest JUVENA index and the past relationship (log-linear model) between the JUVENA time series and next year recruitment. Regarding the threshold changes that may trigger an update assessment, the WG considers that ICES advice based on the precautionary approach should be updated at least whenever the advice provided in July is perceived in December to lead to risk above the threshold of 0.05. Alternatively, the thresholds needed to revise the advice when the risk is revised downwards include other socio-economic factors that cannot be evaluated by this WG, as it will be usually associated to higher allowable levels of catches and should be consulted to the stakeholders. In any case, the WG considers the July advice could be revised routinely once the JUVENA index is reported.

Since July 2010 the European Commission and the Council set the TAC from July to June next year based on the draft long-term management plan for this fishery. This plan was proposed in 2009 by the EC (COM 2009) and it is still waiting for a formal approval. The harvest control rule in this long-term management plan sets the TAC as the 30% of the spawning stock biomass (SSB) estimated in the assessment, which makes use of the most up-to-date estimates from the spring surveys (DEPM and acoustics). The rule was designed to be robust to the unknown levels of recruitments occurring during the management year from July to June next year. As in the case of the ICES July advice based on the short term predictions, the HCR could include a revision of the TAC set currently from July to June according to the tendency of the forecasted population in relation to last assessment. Alternatively a HCR could provide a TAC going from January to December according to a sustainable harvest rate on the forecasted population over the management year. Depending on the final management calendar year adopted, this would involve a first assessment in June to set the initial TAC with a revision in November, or a first assessment in November with a revision in June. However, it is worth noting that any of these changes in the HCR of the current management plan implies changing the basis upon which the HCR was designed. Therefore it would require a re-evaluation of the risk levels associated to different harvest control rules, and in particular their harvest rate, in order to define the best rule according to the management objectives for this fishery. The specific thresholds triggering a revision of the TAC in the interim year should also be evaluated as part of the HCR.

Table 3.2.2.1: Bay of Biscay anchovy: Annual catches (in tonnes).
The catches up to 2011 are estimated by the Working Group members and the catches in 2012 correspond to official records.

COUNTRY	FRANCE	SPAIN	SPAIN	UNALLOCATED	INTERNATIONAL
YEAR	VIIIab	VIIIbc, Landings	Live Bait Catches		VIII
1960	1,085	57,000	n/a		58,085
1961	1,494	74,000	n/a		75,494
1962	1,123	58,000	n/a		59,123
1963	652	48,000	n/a		48,652
1964	1,973	75,000	n/a		76,973
1965	2,615	81,000	n/a		83,615
1966	839	47,519	n/a		48,358
1967	1,812	39,363	n/a		41,175
1968	1,190	38,429	n/a		39,619
1969	2,991	33,092	n/a		36,083
1970	3,665	19,820	n/a		23,485
1971	4,825	23,787	n/a		28,612
1972	6,150	26,917	n/a		33,067
1973	4,395	23,614	n/a		28,009
1974	3,835	27,282	n/a		31,117
1975	2,913	23,389	n/a		26,302
1976	1,095	36,166	n/a		37,261
1977	3,807	44,384	n/a		48,191
1978	3,683	41,536	n/a		45,219
1979	1,349	25,000	n/a		26,349
1980	1,564	20,538	n/a		22,102
1981	1,021	9,794	n/a		10,815
1982	381	4,610	n/a		4,991
1983	1,911	12,242	n/a		14,153
1984	1,711	33,468	n/a		35,179
1985	3,005	8,481	n/a		11,486
1986	2,311	5,612	n/a		7,923
1987	4,899	9,863	546		15,308
1988	6,822	8,266	493		15,581
1989	2,255	8,174	185		10,614
1990	10,598	23,258	416		34,272
1991	9,708	9,573	353		19,634
1992	15,217	22,468	200		37,885
1993	20,914	19,173	306		40,393
1994	16,934	17,554	143		34,631
1995	10,892	18,950	273		30,115
1996	15,238	18,937	198		34,373
1997	12,020	9,939	378		22,337
1998	22,987	8,455	176		31,617
1999	13,649	13,145	465		27,259
2000	17,765	19,230	n/a		36,994
2001	17,097	23,052	n/a		40,149
2002	10,988	6,519	n/a		17,507
2003	7,593	3,002	n/a		10,595
2004	8,781	7,580	n/a		16,361
2005	952	176	0		1,128
2006	913	840	0		1,753
2007	140 **	1.2 **	0		0
2008	0	0	0		0
2009	0	0	0		0
2010	4,573	5,744	n/a		10,317
2011	3,615	10,916	n/a		14,530
2012	5,975	7,896	n/a	531	14,402
2013 (Up end May)	0	7,496	n/a		7,496
AVERAGE (1960-2004)	6,394	26,337	318		32,824

** : Experimental fishery

Table 3.2.2.2: Bay of Biscay anchovy : Monthly catches in Sub-area VIII (without live bait catches)

YEAR\MONTH	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
1987	0	0	454	5246	5237	782	229	636	707	812	309	352	14763
1988	6	0	42	1657	4317	3979	584	1253	2423	445	136	246	15088
1989	706	73	36	588	4943	806	132	566	186	472	1619	301	10429
1990	80	6	2101	2658	11459	3083	1471	5132	5553	1570	652	92	33856
1991	1418	2175	626	2036	6913	1858	215	479	1621	822	238	882	19282
1992	2422	1864	1282	4241	13125	3448	719	1488	3291	3228	2489	89	37685
1993	1738	1864	3362	3260	7906	5927	2110	2979	4254	3342	3273	70	40086
1994	1972	1917	1591	5741	4761	7231	1796	2306	3382	3295	421	74	34487
1995	620	958	842	5967	12329	2764	439	1098	2155	1382	903	387	29843
1996	1132	647	752	1834	9763	6897	2449	2675	3617	2818	1575	17	34176
1997	2278	688	105	2782	2762	1985	1895	2400	3578	2381	921	185	21961
1998	1558	2363	1276	371	4839	2510	3943	5039	4298	2640	2500	104	31442
1999	2088	1360	626	4681	4282	2345	2052	948	4049	2130	2207	27	26794
2000	2219	948	925	1957	11922	4565	3148	3063	4043	2995	1210	0	36994
2001	960	565	479	2249	14428	4413	2514	3403	4435	3850	2852	1	40149
2002	1436	2561	1573	915	2506	2098	673	1034	2970	1152	578	0	17497
2003	39	2	0	1740	890	1403	294	2297	1602	1322	986	20	10595
2004	210	106	3	2377	3247	3241	902	2017	2886	557	813	2	16360
2005	363	17	35	4	183	525	0	0	0	0	0	0	1127
2006	1	0	33	124	630	870	95	0	0	0	0	0	1753
2007	0	0	0	39	57	45	0	0	0	0	0	0	141
2008	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	299	1324	2955	1532	75	632	2425	863	213	0	10317
2011	0	0	1586	4483	4492	351	2	176	815	1319	1258	47	14530
2012	0	0	68	1060	5663	1809	354	868	2352	1940	288	0	14402

Table 3.2.2.3: Bay of Biscay anchovy: Catches by divisions in 2012 (without live bait catches)

	QUARTERS				CATCH (t)	
DIVISIONS	1	2	3	4	ANNUAL	%
VIIIa	0	0	0	0	0	0.0%
VIIIb	5	4913	3196	2210	10324	71.7%
VIIIc	35	3621	393	28	4078	28.3%
TOTAL	40	8534	3589	2238	14402	100.0%
%	0.3%	59.3%	24.9%	15.5%	100.0%	

Table 3.2.3.1: Bay of Biscay anchovy: catch at age in thousands for 2012 by quarter (without the catches from the live bait tuna fishing boats).

2012 units: thousands

	QUARTERS	1	2	3	4	Annual total
	AGE	VIIIabc	VIIIabc	VIIIabc	VIIIabc	VIIIabc
	0	0	0	3,145	616	3,761
	1	2,537	53,476	106,747	61,188	223,948
	2	234	254,629	41,373	28,023	324,259
	3	1	5,054	594	521	6,170
TOTAL	4	0	0	0	0	0
Sub-area VIII	5	0	0	0	0	0
	TOTAL(n)	2,772	313,160	151,859	90,348	558,138
	W MED.	14.52	27.02	22.88	23.76	25.30
	CATCH. (t)	40	8534	3589	2238	14402
	SOP	40	8462	3475	2146	14123
	VAR. %	99.99%	99.15%	96.81%	95.91%	98.06%

Table 3.2.3.2: Bay of Biscay anchovy: Catches at age of anchovy of the fishery in the Bay of Biscay on half year basis (including live bait catches up to 1999)

Units: Thousands

INTERNATIONAL

YEAR	1987		1988		1989		1990		1991		1992		1993		1994		1995	
Age	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0	0	38,140	0	150,338	0	180,085	0	16,984	0	86,647	0	38,434	0	63,499	0	59,934	0	49,771
1	218,670	120,098	318,181	190,113	152,612	27,085	847,627	517,690	323,877	116,290	1,001,551	440,134	794,055	611,047	494,610	355,663	522,361	189,081
2	157,665	13,534	92,621	13,334	123,683	10,771	59,482	75,999	310,620	12,581	193,137	31,446	439,655	91,977	493,437	54,867	282,301	21,771
3	31,362	1,664	9,954	596	18,096	1,986	8,175	4,999	29,179	61	16,960	1	5,336	0	61,667	1,325	76,525	90
4	14,831	58	1,356	0	54	0	0	0	0	0	0	0	0	0	0	0	4,096	7
5	8,920	0	99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total #	431,448	173,494	398,971	529,130	294,445	219,927	915,283	615,671	663,677	215,579	1,211,647	510,015	1,239,046	766,523	1,049,714	471,789	885,283	260,719

YEAR	1996		1997		1998		1999		2000		2001		2002		2003		2004	
Age	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0	0	109,173	0	133,232	0	4,075	0	54,357	0	5,298	0	749	0	267	0	7,530	0	11,184
1	683,009	456,164	471,370	439,888	443,818	598,139	220,067	243,306	559,934	396,961	460,346	507,678	103,210	129,392	50,327	133,083	254,504	252,887
2	233,095	53,156	138,183	40,014	128,854	123,225	380,012	142,904	268,354	64,712	374,424	98,117	217,218	77,128	44,546	87,142	85,679	20,072
3	31,092	499	5,580	195	5,596	3,398	17,761	525	84,437	18,613	19,698	5,095	37,886	3,045	34,133	11,459	12,444	1,153
4	2,213	42	0	0	155	0	108	0	0	0	4,948	0	76	0	887	1,152	4,598	16
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total #	949,408	619,034	615,133	613,329	578,423	728,837	617,948	441,092	912,725	485,584	859,417	611,639	358,390	209,832	129,893	240,366	357,225	285,312

YEAR	2005		2006		2007		2008		2009		2010		2011		2012	
Age	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0	0	0	0	0	0	0	0	0	0	0	0	16,287	0	4,656	0	3,761
1	7,818	0	48,718	3,894	0	0	0	0	0	0	125,198	135,570	164,061	159,675	56,013	167,935
2	32,911	0	17,172	991	0	0	0	0	0	0	77,342	13,864	214,454	11,080	254,863	69,396
3	6,935	0	6,465	320	0	0	0	0	0	0	10,897	815	7,161	503	5,055	1,115
4	586	0	49	2	0	0	0	0	0	0	1,711	189	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	1	0	0	0		
Total #	48,250	0	72,405	5,207	0	0	0	0	0	0	215,149	166,725	385,677	175,914	315,932	242,207

Table 3.2.3.3: Bay of Biscay anchovy: Catch numbers at length quarters in 2012

Length (half cm)	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4
3.5				
4				
4.5				
5				
5.5				
6				
6.5				
7				
7.5				
8				
8.5				
9	8			
9.5	17	1		
10	67	20		
10.5	169	470	41	
11	215	1,498	176	
11.5	269	1,885	645	
12	391	4,839	1,437	
12.5	477	5,705	3,092	
13	423	11,125	5,870	1,459
13.5	311	14,577	7,558	2,918
14	214	20,724	14,218	5,253
14.5	101	27,791	22,299	9,339
15	49	36,770	26,677	16,644
15.5	41	42,174	19,284	22,221
16	8	40,533	17,933	14,720
16.5	6	36,147	14,180	10,727
17	4	30,530	9,534	3,974
17.5		22,977	5,598	1,559
18		11,116	3,235	1,514
18.5		3,266	67	14
19		885	15	3
19.5		97		
20		28		
20.5				
21				
21.5				
22				
22.5				
23				
23.5				
24				
24.5				
25				
25.5				
26				
Total ('000)	2,772	313,160	151,859	90,348
Catch (t)	40	8,534	3,589	2,238
Mean Length(cm)	12.50	15.51	15.19	15.46

Table 3.2.4.1: Bay of Biscay anchovy: Mean weight at age (grammes) in the international catches on half year basis
nits: grams

INTERNATIONAL

YEAR	1987		1988		1989		1990		1991		1992		1993		1994		1995	
Sources	Anon. (1989 & 1991)		Anon. (1989)		Anon. (1991)		Anon. (1991)		Anon. (1992)		Anon. (1993)		Anon. (1995)		Anon. (1996)		Anon. (1997)	
Periods	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
Age 0	na	11.7	na	5.1	na	12.7	na	7.4	na	14.4	na	12.6	na	12.3	na	14.7	na	15.1
1	21.0	21.9	20.8	23.6	19.5	24.9	20.6	23.8	18.5	25.1	19.6	23.0	15.5	20.9	16.8	25.3	22.5	26.9
2	32.0	34.2	30.3	30.4	28.5	35.2	28.5	27.7	25.2	29.0	30.9	28.8	27.0	29.4	26.8	28.1	32.3	31.3
3	37.7	39.2	34.5	44.5	29.7	42.7	44.8	40.8	28.2	39.0	37.7	27.4	30.5	na	30.7	30.0	36.4	36.4
4	41.0	40.0	37.6	na	27.1	na	na	na	na	na	na	na	na	na	na	na	37.3	29.1
5	42.0	0.0	48.5	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Total	27.3	20.8	24.6	10.7	23.9	15.6	21.3	24.0	22.1	21.1	21.7	22.5	19.6	21.2	22.3	24.3	26.9	25.0

YEAR	1996		1997		1998		1999		2000		2001		2002		2003		2004	
Sources:	Anon. (1998)		Anon. (1999)		Anon (2000)		WG data		WG data		WG data		WG data		WG data		WG data	
Periods	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
Age 0	na	12.0	na	11.6	na	10.2	na	15.7	na	19.3	na	14.3	na	9.5	na	15.4	na	15.5
1	19.1	23.2	14.4	20.3	21.8	23.7	17.1	27.0	21.7	28.2	22.7	27.5	25.0	28.8	21.0	25.4	21.7	24.9
2	29.3	27.7	26.9	30.1	24.3	27.7	29.8	33.5	29.1	33.0	31.8	31.1	31.6	33.4	36.2	29.5	35.7	33.5
3	35.0	35.7	32.0	29.7	31.9	28.7	34.7	38.9	32.8	36.9	36.3	38.6	42.8	36.5	40.3	36.4	39.3	40.7
4	46.1	39.7	na	na	31.9	na	55.9	na	na	na	40.7	na	45.6	na	36.9	37.9	44.0	42.8
5	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Total	22.2	21.6	17.3	19.1	22.5	24.3	25.4	27.7	24.9	29.0	27.1	28.2	30.9	30.6	31.4	27.1	26.0	25.2

YEAR	2005		2006		2007		2008		2009		2010		2011		2012	
Sources:	WG data		WG data		WG data		WG data		WG data		WG data		WG data		WG data	
Periods	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
Age 0	na	na	na	na	na	na	na	na	na	na	na	14.4	na	8.9	na	12.6
1	19.3	na	20.3	17.8	na	na	na	na	na	na	25.0	25.9	22.5	20.5	16.7	22.3
2	24.5	na	27.7	19.7	na	na	na	na	na	na	32.1	27.4	32.4	27.3	28.9	25.9
3	27.6	na	31.3	19.7	na	na	na	na	na	na	43.7	43.2	36.4	34.8	38.7	26.5
4	24.5	na	37.3	34.3	na	na	na	na	na	na	43.0	44.4	na	na	na	na
5	na	na	na	na	na	na	na	na	na	na	55.7	na	na	na	na	na
Total	24.1	na	23.0	18.2	na	na	na	na	na	na	28.6	25.0	28.3	20.6	26.9	23.2

Table 3.3.1.1.1: Bay of Biscay anchovy: Details of the DEPM survey BIOMAN 2013.

Parameters	Anchovy DEPM survey
Surveyed area	(43º17' to 47º23'N & 4º14' to 1º30' W)
R/V	*Ramón Margalef* & *Emma Bardán*
Date	9-28/05/13
Eggs	R/V RAMON MARGALEF
Total egg stations	551
% st with anchovy eggs	52%
Anchovy egg average by st	16 eggs/0.1m^2
Max. anchovy eggs in a St	569 eggs/0.1m^2
Total anchovy egg collected	8,830 eggs
North spawning limit	46º15'N
South spawning limit	43º45'N
Total area surveyed	77,838 Km^2
Spawning area	35,448 Km^2
CUFES stations	1,222
Adults	R/V EMMA BARDAN
Pelag. trawls	30
With anchovy	22
Selected for analysis	21

Table 3.3.1.2.1: Bay of Biscay anchovy: Daily egg production (P_0), daily egg mortality rates (z) and total egg production (P_{tot}) estimates with their correspondent standard error (s.e.) and coefficient of variation (CV) for 2013.

Parameter	Value	S.e.	CV
P_0	91.51	13.97	0.1526
z	0.21	0.071	0.3421
P_{tot}	3.24.E+12	5.0.E+11	0.1526

Table: 3.3.1.3.1: Bay of Biscay anchovy: All the parameters to estimate de index of biomass using the Daily Egg Production Method (DEPM) for 2013: Ptot (total egg production), R (sex ratio), S(Spawning frequency), F (batch fecundity), Wf (female mean weight), DF (daily fecundity) and Wt (total mean weight(female and male) with correspondent Standard errors (S.e.) and coefficients of variation (CV).

a) Index of biomass with the average of the new historical series of S (0.40)

Parameter	estimate	S.e.	CV
Ptot	3.24E+12	4.95E+11	0.1526
R'	0.53	0.0044	0.0083
S	0.40	0.0141	0.0353
F	8,217	794	0.0967
Wf	21.87	1.76	0.0805
DF	79.51	3.73	0.0469
BIOMASS	40,797	6,514	0.1597
Wt	16.81	2.69	0.1597

b) Index of biomass with the average of the traditional historical series of S (0.25)

Parameter	estimate	S.e.	CV
Ptot	3.24E+12	4.95E+11	0.1526
R'	0.53	0.0044	0.0083
S	0.25	0.0087	0.0353
F	8,217	794	0.0967
Wf	21.87	1.76	0.0805
DF	49.22	2.31	0.0469
BIOMASS	65,909	10,523	0.1597
Wt	16.81	2.69	0.1597

Table: 3.3.1.4.1: Bay of Biscay anchovy: index of biomass, percentage at age, numbers at age, mean weight by age class, biomass at age in mass and percentage at age in mass and the correspondent standard error (s.e.) and coefficient of variation (CV) from BIOMAN 2013.

a) Index of biomass with the average of the new historical series of S (0.40)

Parameter	estimate	S.e.	CV
Biomass (Tons)	40,797	6,514	0.1597
Tot. Mean W (g)	16.81	2.69	0.1597
Population (millions)	2,494	585	0.2345
Percent. age 1	0.59	0.09	0.1539
Percent. age 2	0.32	0.06	0.1988
Percent. age 3	0.08	0.03	0.3745
Numbers at age 1	1,515	547	0.3614
Numbers at age 2	781	136	0.1742
Numbers at age 3	198	55	0.2760
Weight at age 1 (g)	11.7		
Weight at age 2 (g)	22.8		
Weight at age 3 (g)	30.0		
Biomass at age 1 (Ton)	17,421		
Biomass at age 2 (Ton)	17,522		
Biomass at age 3 (Ton)	5,854		
Percet. at age 1 in mass	42.7		
Percent. at age 2 in mass	42.9		
Percent. at age 3in mass	14.3		

b) Index of biomass with the average of the traditional historical series of S (0.25)

Parameter	estimate	S.e.	CV
Biomass (Tons)	65,909	10,523	0.1597
Tot. Mean W (g)	16.81	2.69	0.1597
Population (millions)	4,029	945	0.2345
Percent. age 1	0.59	0.09	0.1539
Percent. age 2	0.32	0.06	0.1988
Percent. age 3	0.08	0.03	0.3745
Numbers at age 1	2,447	884	0.3614
Numbers at age 2	1,262	220	0.1742
Numbers at age 3	320	88	0.2760
Weight at age 1 (g)	11.7		
Weight at age 2 (g)	22.8		
Weight at age 3 (g)	30.0		
SSB at age 1 (Tons)	28,144		
SSB at age 2 (Tons)	28,308		
SSB at age 3 (Tons)	9,458		
Percet. at age 1 in mass	42.7		
Percent. at age 2 in mass	42.9		
Percent. at age 3in mass	14.3		

Table 3.3.2.1 : Acoustic biomass index for sardine and anchovy by strata during PELGAS13

	Classic	Surface	total
anchovy	68 710	25 144	93 854
sardine	366 378	41 363	407 740
sprat	44 651		44 651
mackerel	627 418	105 320	732 739
horse mackerel	33 471		33 471
blue whiting	51 430		51 430

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
anchovy	**113 120**	**105 801**	**110 566**	**30 632**	**45 965**	**14 643**	**30 877**	**40 876**	**37 574**	**34 855**	**86 354**	**142 601**	**186 865**	**93 854**
CV anchovy	*0.064*	*0.141*	*0.113*	*0.132*	*0.167*	*0.171*	*0.136*	*0.100*	*0.162*	*0.112*	*0.147*	*0.0774*	*0.0466*	*0.1282*
Sardine	**376 442**	**383 515**	**563 880**	**111 234**	**496 371**	**435 287**	**234 128**	**126 237**	**460 727**	**479 684**	**457 081**	**338 468**	**205 627**	**407 740**
CV sardine	*0.083*	*0.117*	*0.088*	*0.241*	*0.121*	*0.135*	*0.117*	*0.159*	*0.139*	*0.098*	*0.091*	*0.0699*	*0.0767*	*0.0738*
Sprat	**30 034**	**137 908**	**77 812**	**23 994**	**15 807**	**72 684**	**30 009**	**17 312**	**50 092**	**112 497**	**67 046**	**34 726**	**6 417**	**44 651**
CV sprat	*0.098*	*0.155*	*0.120*	*0.198*	*0.178*	*0.228*	*0.162*	*0.132*	*0.268*	*0.108*	*0.108*			*0.1992*
Horse mackerel	**230 530**	**149 053**	**191 258**	**198 528**	**186 046**	**181 448**	**156 300**	**45 098**	**100 406**	**56 593**	**11 662**	**61 237**	**7 435**	**33 471**
CV HM	*0.079*	*0.204*	*0.156*	*0.137*	*0.287*	*0.160*	*0.316*	*0.065*	*0.455*	*0.09*	*0.188*			*0.3007*
Blue Whiting	-	-	**35 518**	**1 953**	**12 267**	**26 099**	**1 766**	**3 545**	**576**	**4 333**	**48 141**	**11 823**	**68 533**	**25 715**
CV BW	-	-	*0.386*	*0.131*	*0.202*	*0.593*	*0.210*	*0.147*	*0.253*	*0.219*	*0.074*			*0.1542*

Table 3.3.2.2. Acoustic biomass index for the five main pelagic species since the beginning of PELGAS surveys (2000)

Table 3.3.1.2: Synthesis of the abundance estimation (acoustic index of biomass) for the ten years of surveys.

Year	Sampled area (mn^2)	Posit area (mn^2)	Size juv (cm)	Biom Juvenile (year y)
2003	16,829	3,476	7.9	98,601
2004	12,736	1,907	10.6	2,406
2005	25,176	7,790	6.7	134,131
2006	27,125	7,063	8.1	78,298
2007	23,116	5,677	5.4	13,121
2008	23,325	6,895	7.5	20,879
2009	34,585	12,984	9.1	178,028
2010	40,500	21,110	8.3	599,990
2011	37,500	21,063	6.0	207,625
2012	31,724	14,271	6.4	142,083

Table 3.3.4.1: Synthesis of the abundance estimation (acoustic index of biomass) for Juvena 2012 for each of the main strata

Stratum	Nasc	Area	juv Lenth	juv Biom
Pure juvenile area	318	8240	6.3	128997
Mixed area	327	4806	10.92	5701
Garonne	397	1224	10.75	7385
Total		14271	6.40	142083

Table 3.5.1.1: Bay of Biscay anchovy: Input data for BBM.

			CATCH DATA			DEPM		ACOUSTICS	
Year	**h1**	**h2**	**C(y,1,1)**	**C(y,1,1+)**	**C(y,2,1+)**	**B(y,1)**	**B(y,1+)**	**B(y,1)**	**B(y,1+)**
1987	0.3068	0.1940	2711	8318	6543	14235	29365	NA	NA
1988	0.3253	0.1774	2602	3864	10954	53087	63500	NA	NA
1989	0.2820	0.2328	1723	3876	4442	7282	16720	6476	15500
1990	0.3070	0.2057	9314	10573	23574	90650	97239	NA	NA
1991	0.2347	0.1984	3903	10191	8196	11271	19276	28322	64000
1992	0.2542	0.2184	11933	16366	21026	85571	90720	84439	89000
1993	0.2368	0.2378	6414	14177	25431	NA	NA	NA	NA
1994	0.2331	0.2050	3795	13602	20150	34674	60062	NA	35000
1995	0.2917	0.1751	5718	14550	14815	42906	54700	NA	NA
1996	0.2756	0.1978	4570	9246	23833	NA	39545	NA	NA
1997	0.2078	0.2624	4323	7235	13256	38536	51176	38498	63000
1998	0.1992	0.2567	5898	7988	23588	80357	101976	NA	57000
1999	0.2304	0.2626	2067	10895	15511	NA	69074	NA	NA
2000	0.2569	0.1999	6298	12010	24882	NA	44973	89363	113120
2001	0.2984	0.2195	5481	11468	28671	69110	120403	67110	105801
2002	0.1833	0.2389	1962	7738	9754	6352	30697	27642	110566
2003	0.2997	0.2795	625	2379	8101	16575	23962	18687	30632
2004	0.2989	0.2126	2754	4623	11657	14649	19498	33995	45965
2005	0.1138	0.0741	102	790	372	2063	8002	2467	14643
2006	0.3266	0.0741	484	815	947	15064	21436	18282	30877
2007	0.3181	0.0590	20	67	73	16030	25973	26230	40876
2008	0.2610	0.1991	0	0	0	7579	25377	10400	37574
2009	0.2610	0.1994	0	0	0	9295	24846	11429	34855
2010	0.3134	0.2221	1723	3447	6655	33725	42979	64564	86355
2011	0.2927	0.2575	2747	8307	6182	140555	172223	115379	142601
2012	0.3349	0.2128	446	3900	10176	13959	41742	73843	186865
2013	0.3194	NA	1074	4960	NA	28144	65909	42508	93854

h1 and h2 denote the fractions of year to the time point within each period when commercial catch is assumed to take place

Table 3.5.1.2: Bay of Biscay anchovy: Median and 95% probability intervals for recruitment, spawning stock biomass, harvest rates (Catch/SSB) and the ratio of SSB with respect to SSB in 1989 as resulted from BBM.

	R (tonnes)			SSB (tonnes)			Harvest rate			SSB/SSB_{1989}		
Year	**2.50%**	**Median**	**97.50%**	**2.50%**	**Median**	**97.50%**	**2.50%**	**Median**	**97.50%**	**2.50%**	**Median**	**97.50%**
1987	14340	16990	22771	18440	21820	29340	0.507	0.681	0.806	0.957	1.286	1.640
1988	35900	41140	51081	31400	35460	45080	0.329	0.418	0.472	1.766	2.082	2.359
1989	9260	11560	15950	13660	17065	24730	0.336	0.487	0.609	1.000	1.000	1.000
1990	81050	89130	105800	58480	65110	79490	0.430	0.524	0.584	2.869	3.792	4.973
1991	20860	26230	34500	23820	30450	42491	0.433	0.604	0.772	1.259	1.759	2.454
1992	87830	140700	241700	60960	104800	188700	0.198	0.357	0.613	3.502	6.008	10.363
1993	33290	89555	126203	85120	97140	115300	0.344	0.408	0.465	3.834	5.705	7.431
1994	39380	48960	65881	50380	59600	78590	0.429	0.566	0.670	2.301	3.481	4.905
1995	35040	56575	101700	27900	48650	91930	0.319	0.604	1.053	1.557	2.774	5.476
1996	37407	67590	88151	51880	59690	73491	0.450	0.554	0.638	2.475	3.477	4.636
1997	39910	52780	71320	38660	50930	69810	0.294	0.402	0.530	1.941	2.957	4.355
1998	54040	82080	132603	47770	74425	120503	0.262	0.424	0.661	2.529	4.322	7.219
1999	41310	78790	117400	54310	75920	102800	0.257	0.348	0.486	2.685	4.387	6.429
2000	107000	131600	154400	101900	121100	134700	0.274	0.305	0.362	4.633	7.079	8.897
2001	75230	84390	101000	92330	101400	113400	0.354	0.396	0.435	4.124	5.945	7.524
2002	10600	12970	18400	32610	37795	46150	0.379	0.463	0.536	1.556	2.214	2.927
2003	24850	31670	38051	29030	35680	43280	0.242	0.294	0.361	1.394	2.084	2.721
2004	36810	46500	57480	35400	44750	55480	0.293	0.364	0.460	1.672	2.617	3.494
2005	4131	6648	9137	14140	20300	27340	0.043	0.057	0.082	0.690	1.186	1.687
2006	20450	29530	39690	22680	32230	42971	0.041	0.055	0.078	1.085	1.883	2.681
2007	26770	36350	48532	32920	43870	57160	0.002	0.003	0.004	1.623	2.554	3.564
2008	8753	12960	18120	24360	32200	41681	0.000	0.000	0.000	1.207	1.876	2.604
2009	9311	13010	18000	20370	26350	34250	0.000	0.000	0.000	0.993	1.541	2.122
2010	48100	61755	81031	45590	57885	74860	0.135	0.175	0.222	2.198	3.385	4.655
2011	96650	128400	176603	89010	117100	160103	0.090	0.124	0.163	4.470	6.800	9.850
2012	26240	37650	57171	59440	81245	116000	0.121	0.173	0.237	3.102	4.685	6.888
2013	21300	32860	53330	36220	56055	88925	0.056	0.088	0.137	1.999	3.194	5.057

Table 3.5.1.3: Bay of Biscay anchovy: Summary table of the current state of the stock from BBM.

R_{2013}	Median	32 860
	95 % C.I.	(21 300, 53 330)
SSB_{2013}	Median	56 055
	95 % C.I.	(36 220, 88 925)
SSB_{2013} / SSB_{1989}	Median	3.194
	95 % C.I.	(1.998, 5.057)
P(SSB_{2013} < 21 000)		0

Table 3.6.3.1: Bay of Biscay anchovy: Probability of SSB in 2014 of being below B_{lim} under the undetermined recruitment scenario under different catch options from 1st July 2013 to 30th June 2014 and alternative catch allocation by semesters.

P(SSB<B_{lim})			% CATCHES IN THE 2nd SEMESTER 2013										
			0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
R undetermined	TOTAL CATCH (July 2013 - June 2014)	0	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		5000	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
		10000	0.011	0.012	0.012	0.013	0.013	0.014	0.015	0.016	0.016	0.017	0.018
		15000	0.028	0.029	0.032	0.033	0.034	0.036	0.038	0.040	0.041	0.043	0.045
		20000	0.053	0.056	0.058	0.061	0.064	0.068	0.071	0.074	0.077	0.080	0.083
		25000	0.087	0.091	0.095	0.100	0.104	0.108	0.112	0.116	0.119	0.124	0.129
		30000	0.124	0.129	0.134	0.138	0.143	0.149	0.154	0.159	0.164	0.169	0.174
		33000	0.146	0.152	0.158	0.163	0.169	0.174	0.180	0.185	0.190	0.196	0.202

Table 3.6.3.2: Bay of Biscay anchovy: Median SSB in 2014 under the undetermined recruitment scenario under different catch options from 1st July 2013 to 30th June 2014 and alternative catch allocation by semesters.

SSBmedian			% CATCHES IN THE 2nd SEMESTER 2013										
			0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
R undetermined	TOTAL CATCH (July 2013 - June 2014)	0	62692	62692	62692	62692	62692	62692	62692	62692	62692	62692	62692
		5000	59997	59936	59876	59816	59755	59695	59635	59575	59514	59454	59394
		10000	57302	57181	57061	56940	56819	56699	56578	56458	56337	56216	56096
		15000	54607	54426	54245	54064	53883	53702	53522	53341	53160	52979	52798
		20000	51912	51671	51430	51188	50947	50706	50465	50224	49982	49741	49500
		25000	49217	48916	48614	48313	48011	47710	47408	47107	46805	46504	46202
		30000	46522	46161	45799	45437	45075	44713	44352	43990	43628	43266	42904
		33000	44905	44507	44109	43711	43313	42915	42518	42120	41722	41324	40926

Table 3.6.3.1: Bay of Biscay anchovy: Probability of SSB in 2014 of being below B_{lim} under the undetermined recruitment scenario under different catch options from 1st July 2013 to 30th June 2014 and alternative catch allocation by semesters.

P(SSB<B_{lim})			% CATCHES IN THE 2nd SEMESTER 2013										
			0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
R undetermined	TOTAL CATCH (July 2013 - June 2014)	0	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		5000	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
		10000	0.011	0.012	0.012	0.013	0.013	0.014	0.015	0.016	0.016	0.017	0.018
		15000	0.028	0.029	0.032	0.033	0.034	0.036	0.038	0.040	0.041	0.043	0.045
		20000	0.053	0.056	0.058	0.061	0.064	0.068	0.071	0.074	0.077	0.080	0.083
		25000	0.087	0.091	0.095	0.100	0.104	0.108	0.112	0.116	0.119	0.124	0.129
		30000	0.124	0.129	0.134	0.138	0.143	0.149	0.154	0.159	0.164	0.169	0.174
		33000	0.146	0.152	0.158	0.163	0.169	0.174	0.180	0.185	0.190	0.196	0.202

Table 3.6.3.2: Bay of Biscay anchovy: Median SSB in 2014 under the undetermined recruitment scenario under different catch options from 1st July 2013 to 30th June 2014 and alternative catch allocation by semesters.

SSBmedian			% CATCHES IN THE 2nd SEMESTER 2013										
			0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
R undetermined	TOTAL CATCH (July 2013 - June 2014)	0	62692	62692	62692	62692	62692	62692	62692	62692	62692	62692	62692
		5000	59997	59936	59876	59816	59755	59695	59635	59575	59514	59454	59394
		10000	57302	57181	57061	56940	56819	56699	56578	56458	56337	56216	56096
		15000	54607	54426	54245	54064	53883	53702	53522	53341	53160	52979	52798
		20000	51912	51671	51430	51188	50947	50706	50465	50224	49982	49741	49500
		25000	49217	48916	48614	48313	48011	47710	47408	47107	46805	46504	46202
		30000	46522	46161	45799	45437	45075	44713	44352	43990	43628	43266	42904
		33000	44905	44507	44109	43711	43313	42915	42518	42120	41722	41324	40926

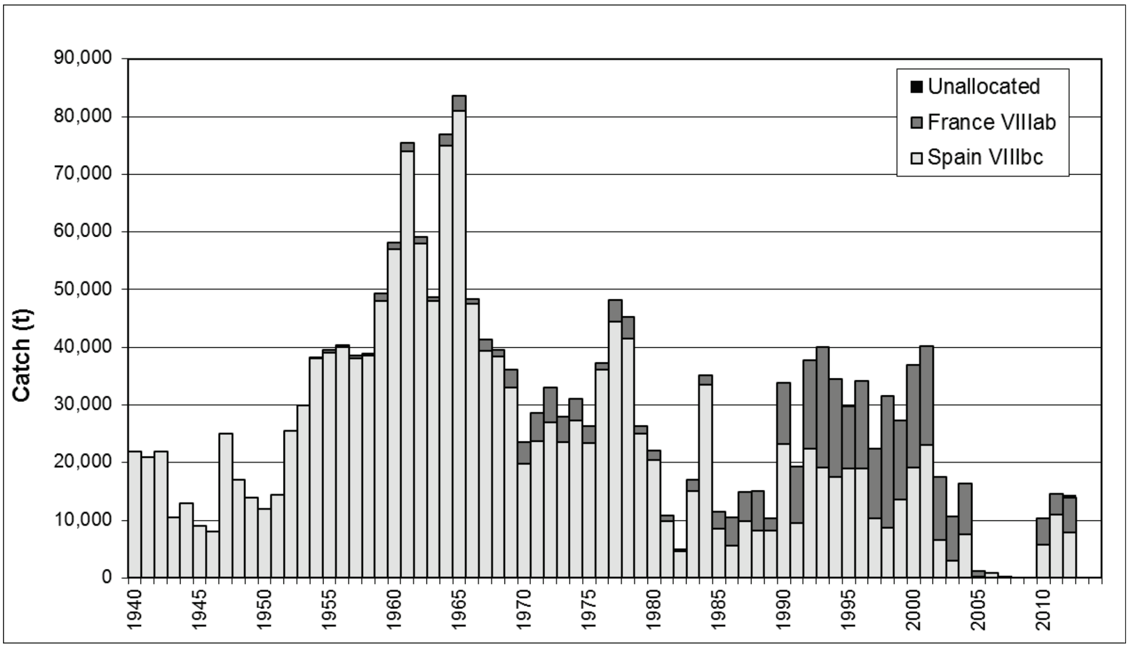


Figure 3.2.2.1: Bay of Biscay anchovy: Historical evolution of catches in division VIII by countries. Catches until 2011 are working group estimates.

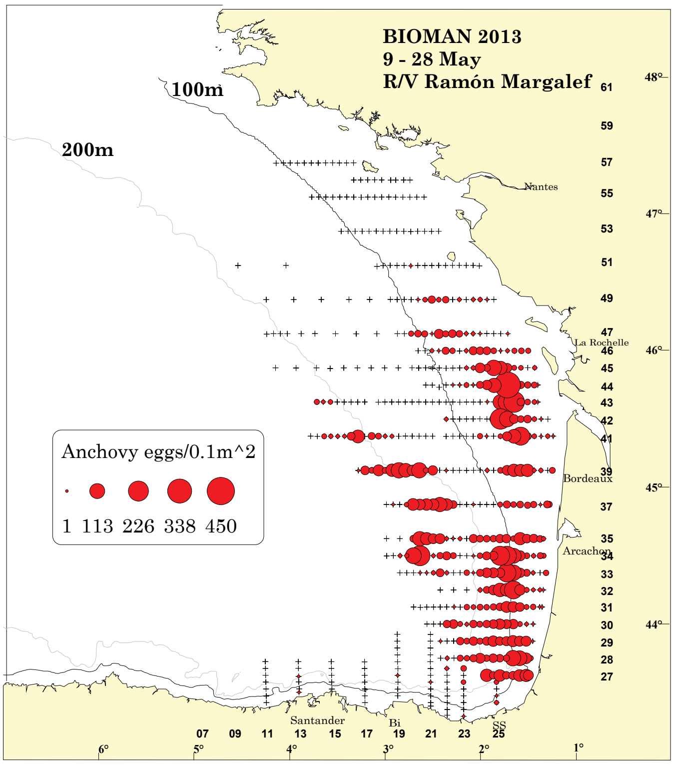


Figure 3.3.1.1.1: Bay of Biscay anchovy: Distribution of egg abundance (eggs per 0.1 m²) from the DEPM survey BIOMAN2013 obtained with PairoVET.

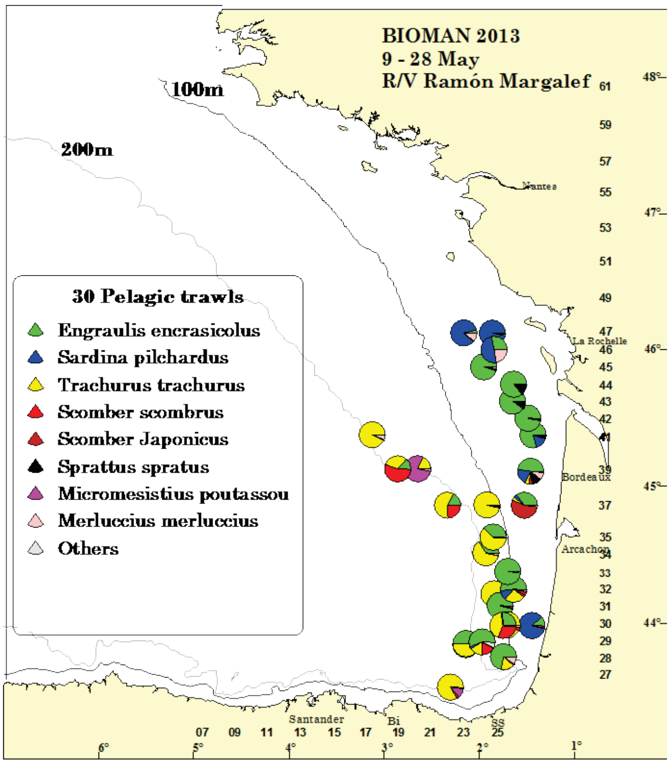
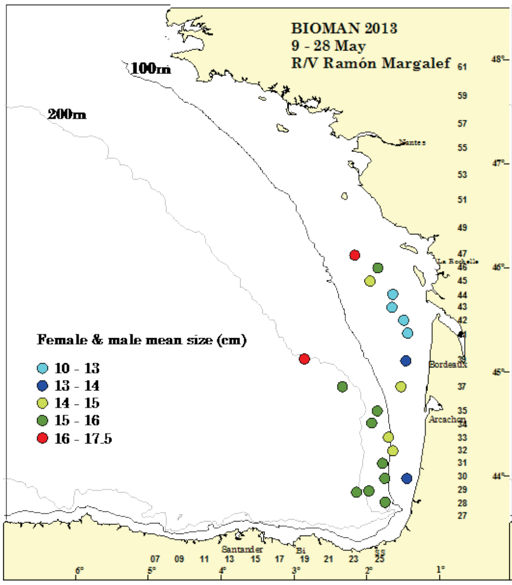


Figure 3.3.1.1.2: Bay of Biscay anchovy: Species composition of the 30 pelagic trawls from the R/V Emma Bardán during BIOMAN2013.



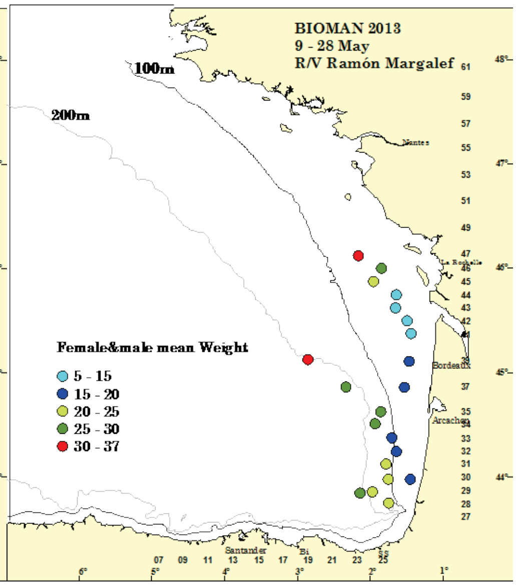


Figure 3.3.1.1.3: Bay of Biscay anchovy: Spatial distribution of the mean size (left) and mean weight (right) (males and females) per haul in BIOMAN2013.

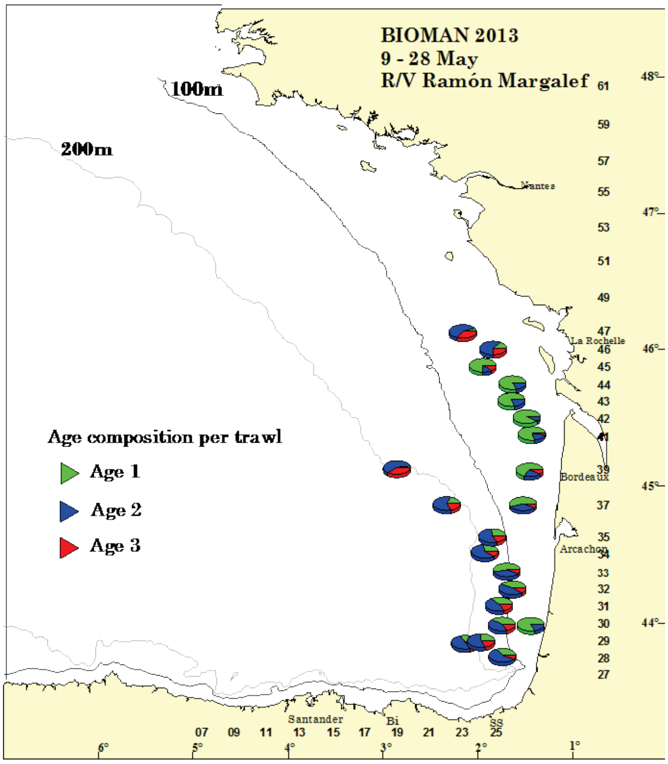


Figure 3.3.1.1.4: Bay of Biscay anchovy: Age composition per haul in BIOMAN2013.

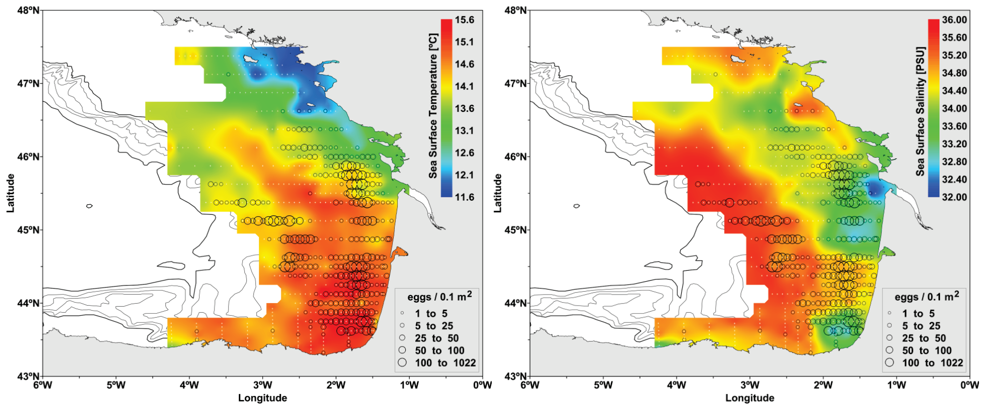


Figure 3.3.1.1.5: Bay of Biscay anchovy: From left to right spatial distribution of SST and SSS in BIOMAN 2013. The bubbles represent the anchovy egg abundance per $0.1m^2$.

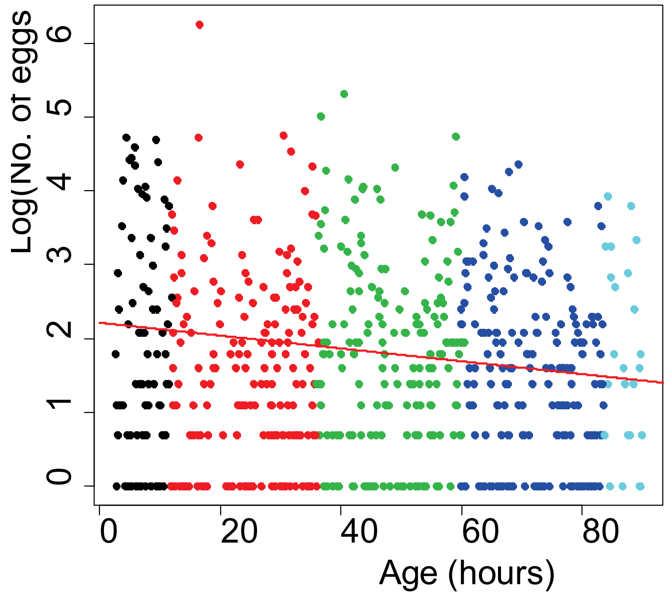


Figure 3.3.1.2.1: Bay of Biscay anchovy: Exponential mortality model adjusted applying a GLM to the data obtained in the Bayesian egg ageing (spawning peak assumed to be at 23:00h).The red line is the adjusted line. The point colours represent the different cohorts.

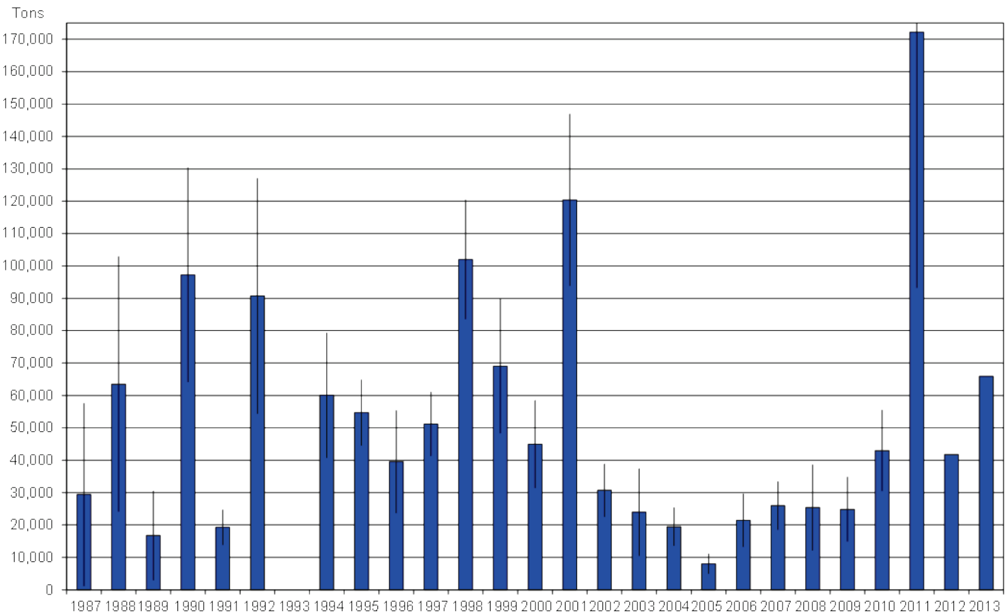


Figure 3.3.1.3.1: Bay of Biscay anchovy: Series of biomass estimates (in tonnes) obtained from the DEPM. In 1996, 1999, 2000, 2007-2013 spawning fraction was deduced indirectly.

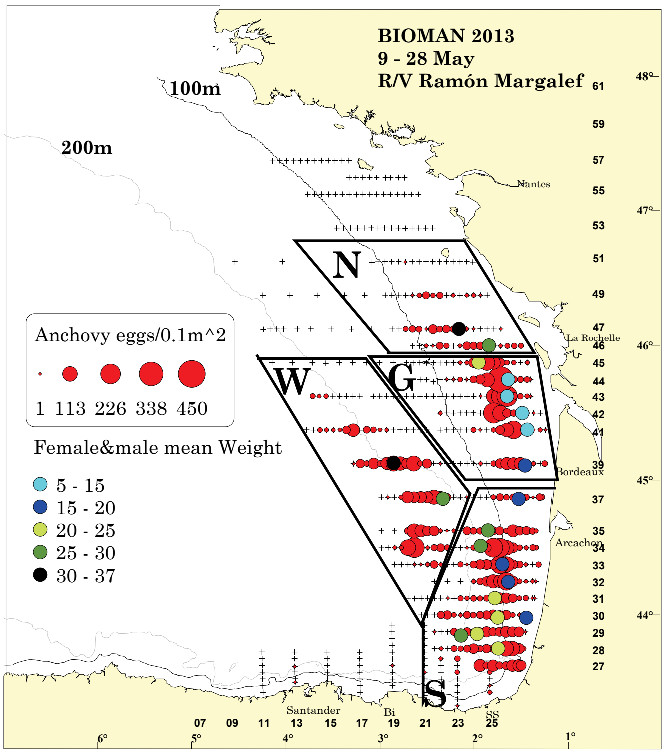


Figure 3.3.1.4.1: Bay of Biscay anchovy: Spatial strata to estimate the numbers at age in BIOMAN2013.

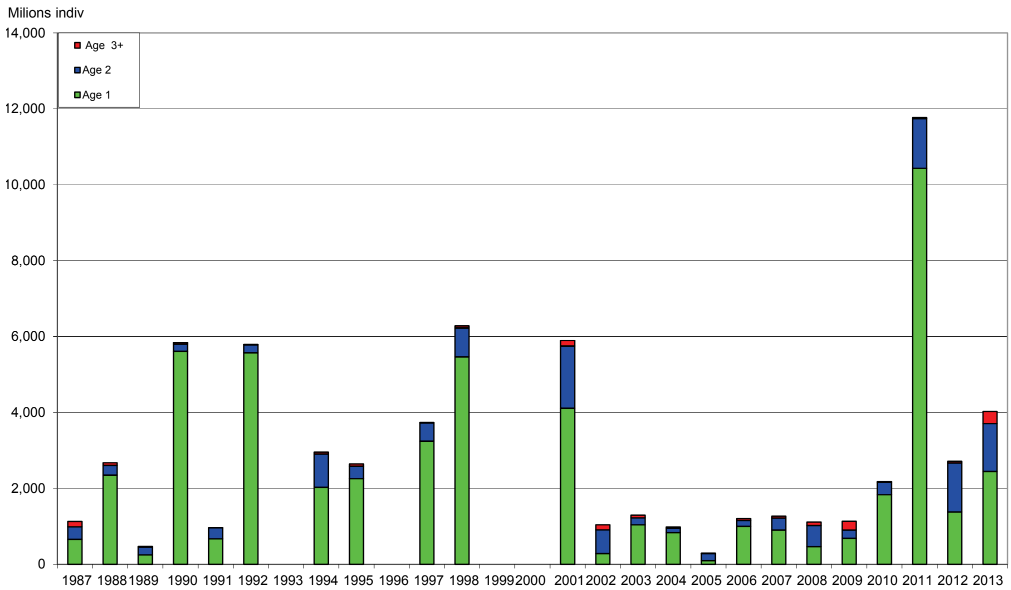


Figure 3.3.1.4.2: Bay of Biscay anchovy: Historical series of numbers at age from 1987 to 2013 from BIOMAN surveys.

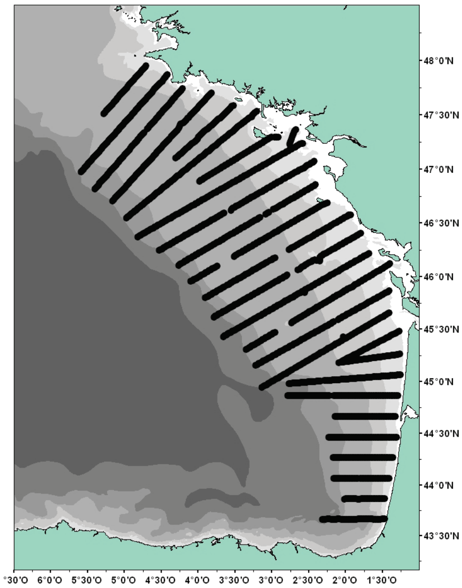


Figure 3.3.2.1. Acoustic transects network during PELGAS13 survey

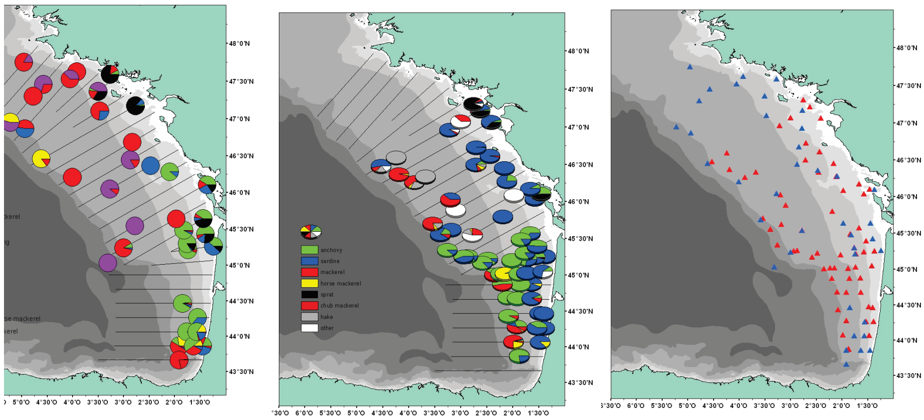
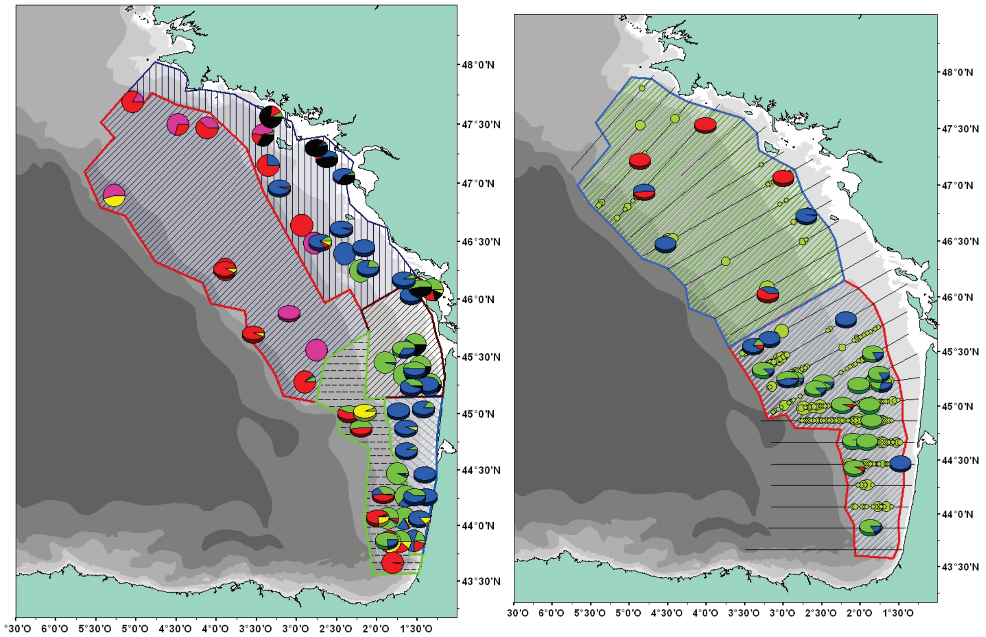


Figure 3.3.2.2 Species composition of the fishing operations carried out by Thalassa (left panel) and commercial vessels (mid panel) during consort survey PELGAS13. On the right panel all the fishing operations are shown (operations by Thalassa in blue and by the commercial vessels in red).



Classic strata

Surface strata

Figure 3.3.2.3. Coherent strata (for classic and surface echotraces) according to species distributions for abundance indices estimates.

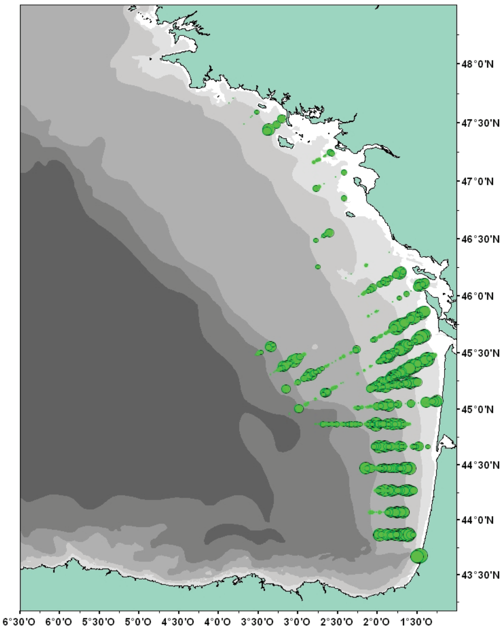


Figure 3.3.2.4. Adult anchovy distribution (density / ESDU)

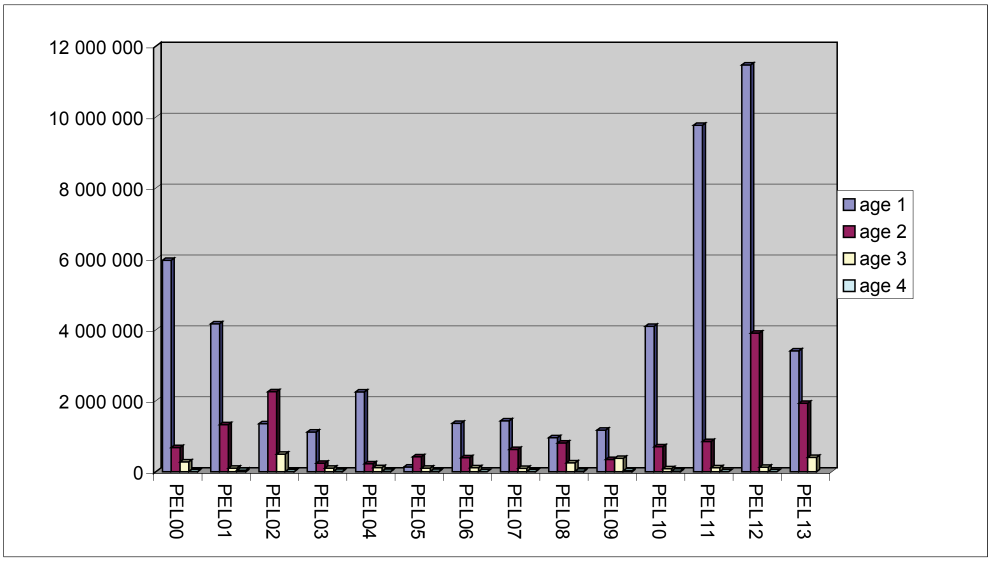


Figure 3.3.2.5. Age distribution of anchovy along PELGAS series.

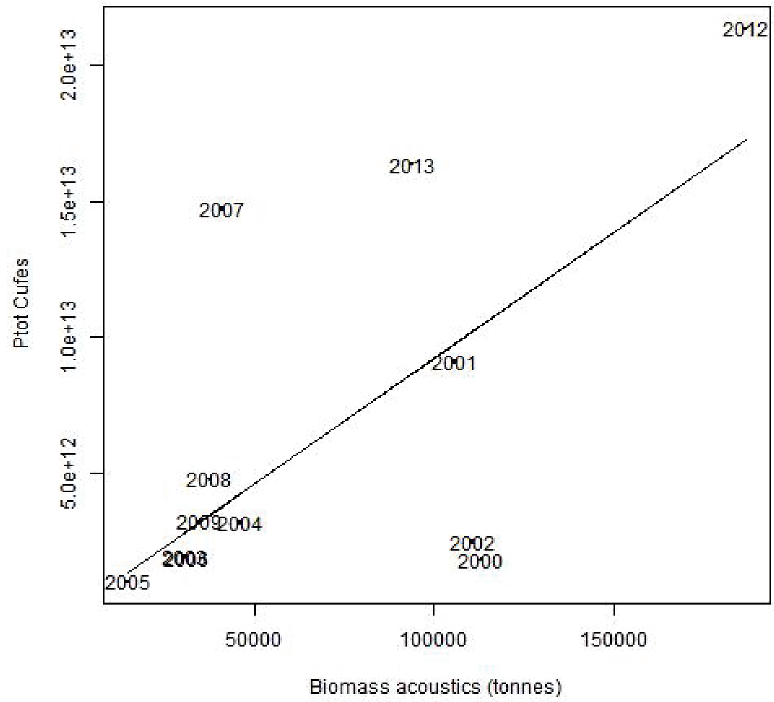


Fig. 3.3.3.1: Relationship between total daily egg production Ptot as estimated from CUFES surveys and spawning biomass as estimated from acoustics. The regression line is forced to pass by the origin. Slope= DF= 92.26 eggs g-1. R-squared= 0.69.

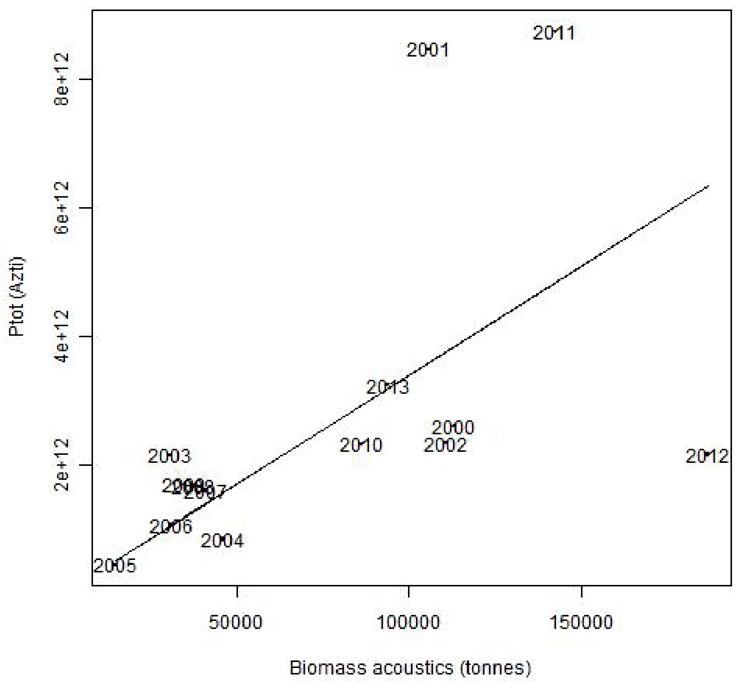


Fig. 3.3.3.2.: Relationship between total daily egg production Ptot as estimated from BIOMAN surveys and spawning biomass as estimated from PELGAS surveys. The regression line is forced to pass by the origin. Slope= DF= 33.88 eggs g-1. R-squared= 0.68.

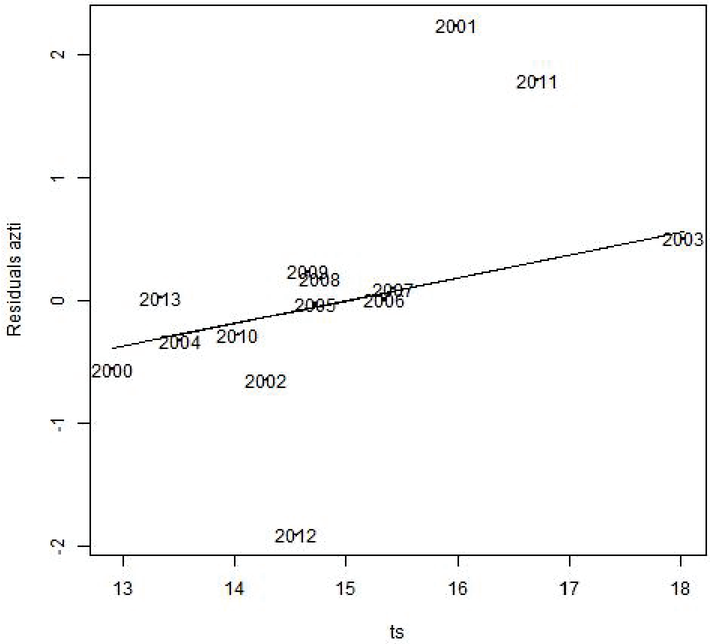


Fig. 3.3.3.3: Variation of the (standardized) residuals on Fig. 1 with surface temperature (ts). The regression line is calculated without the large residuals in years 2001, 2011, 2012.

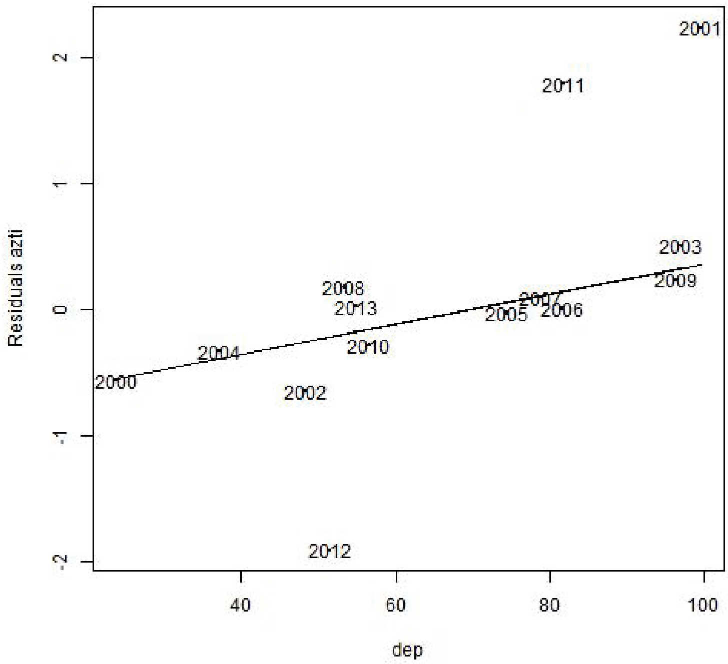


Fig. 3.3.3.4 : Variation of the (standardized) residuals on Fig. 5.4.1 with deficit of potential energy (dep). The regression line is calculated without the large residuals in years 2001, 2011, 2012.

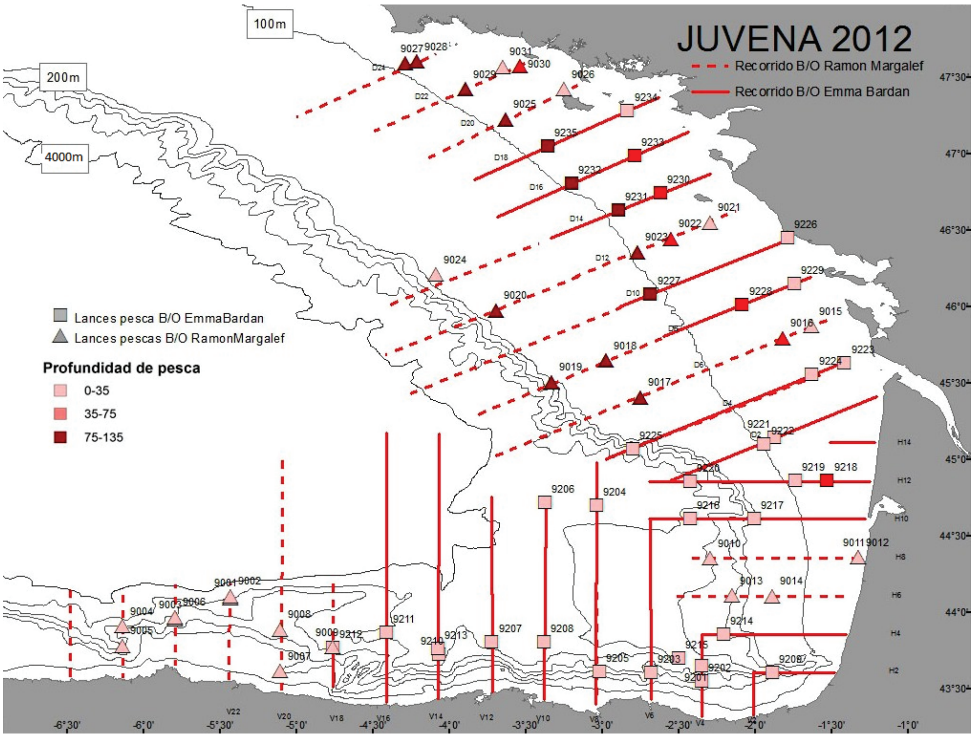


Figure 3.3.4.1: Bay of Biscay anchovy: Position of the fishing stations. Hauls performed by R/V Emma Bardán (EB) are numbered from 9001 to 9030 and the transects are marked with solid lines; hauls performed in the R/V Ramón Margalef (RM) are numbered from 9201 to 9235 and the transects are marked with dashed lines.

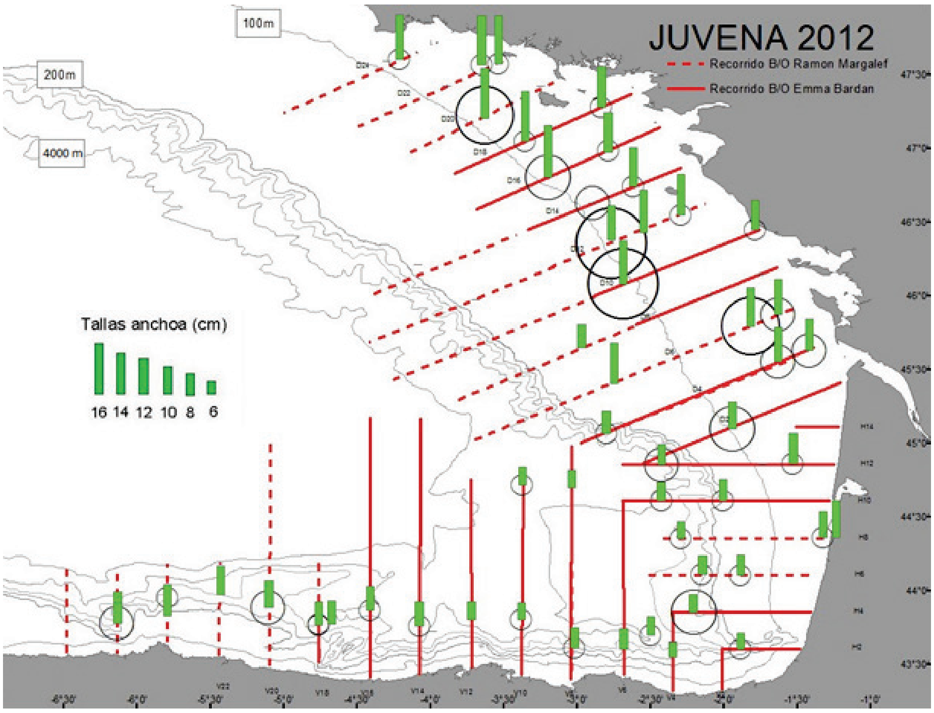


Figure 3.3.4.2: Bay of Biscay anchovy: The circles represent the positive anchovy hauls. The diameter of the circles is proportional to the captured weight of anchovy. The length of the bars is proportional to the mode of the size (standard length) of the captured anchovy.

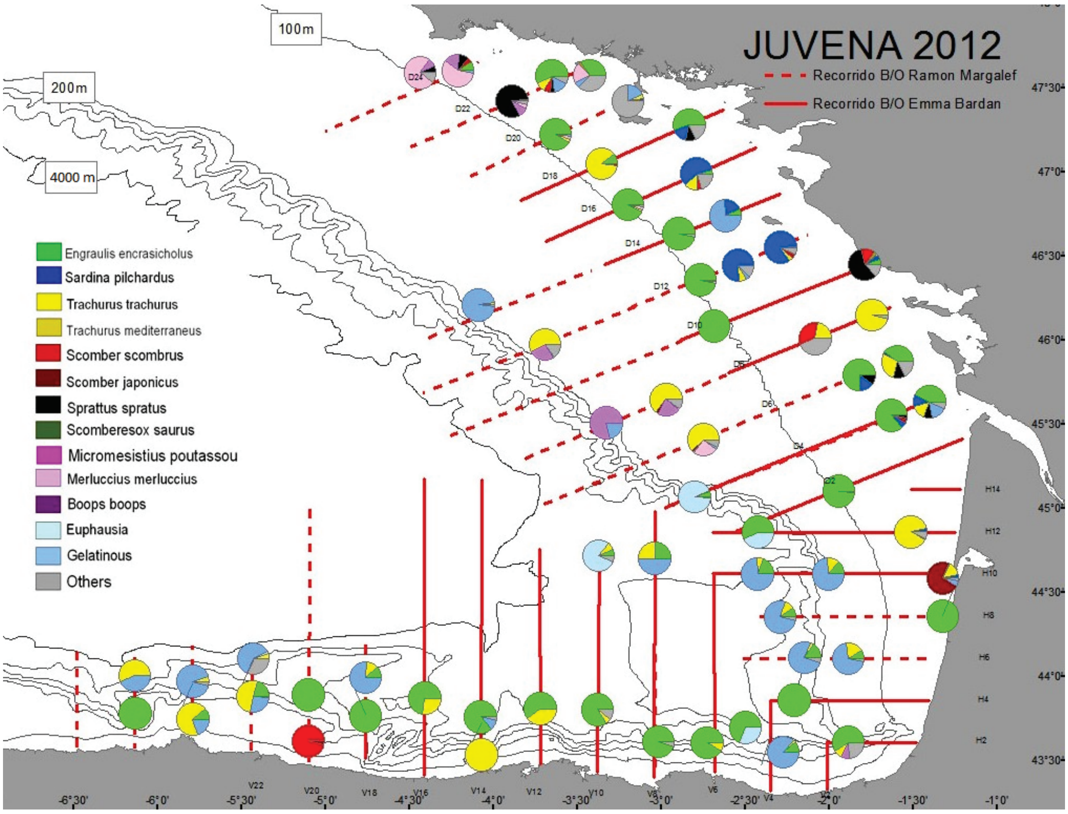


Figure 3.3.4.3: Bay of Biscay anchovy: Species composition of the hauls in JUVENA 2012.

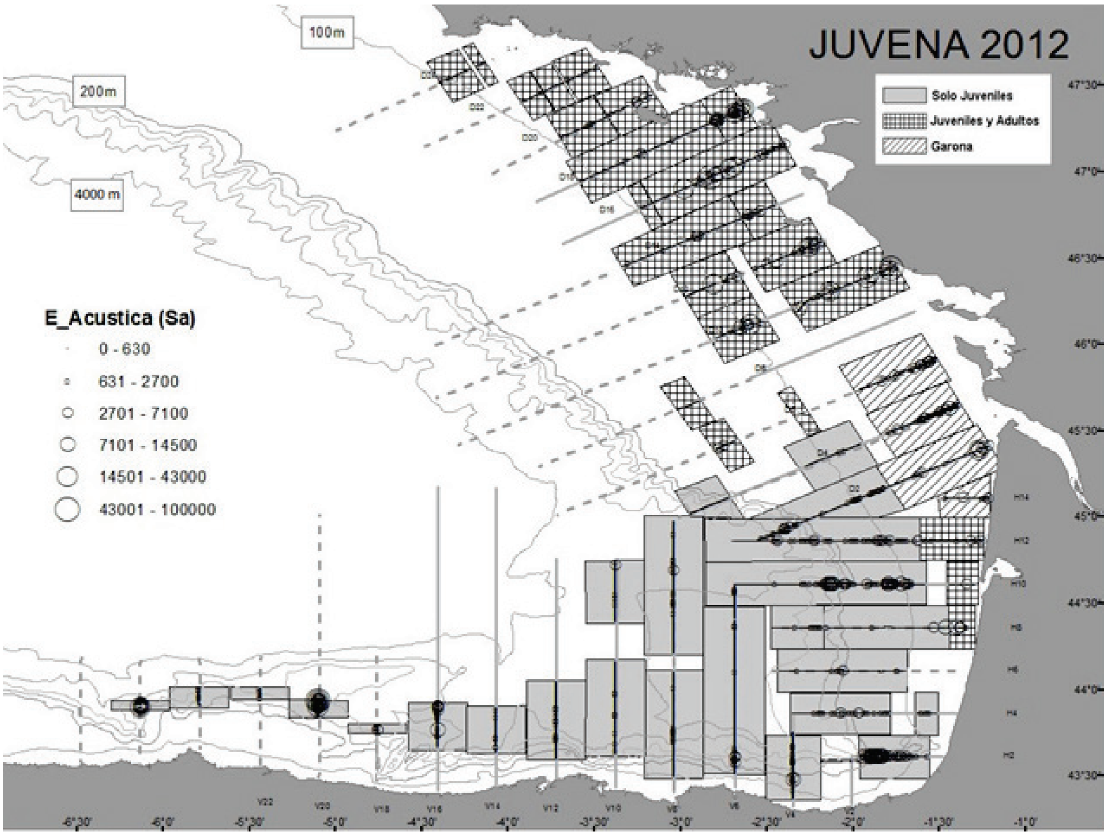


Figure 3.3.4.4: Bay of Biscay anchovy: Total acoustic energy (NASC) of all the identified species and the three subareas of the positive area for anchovy.

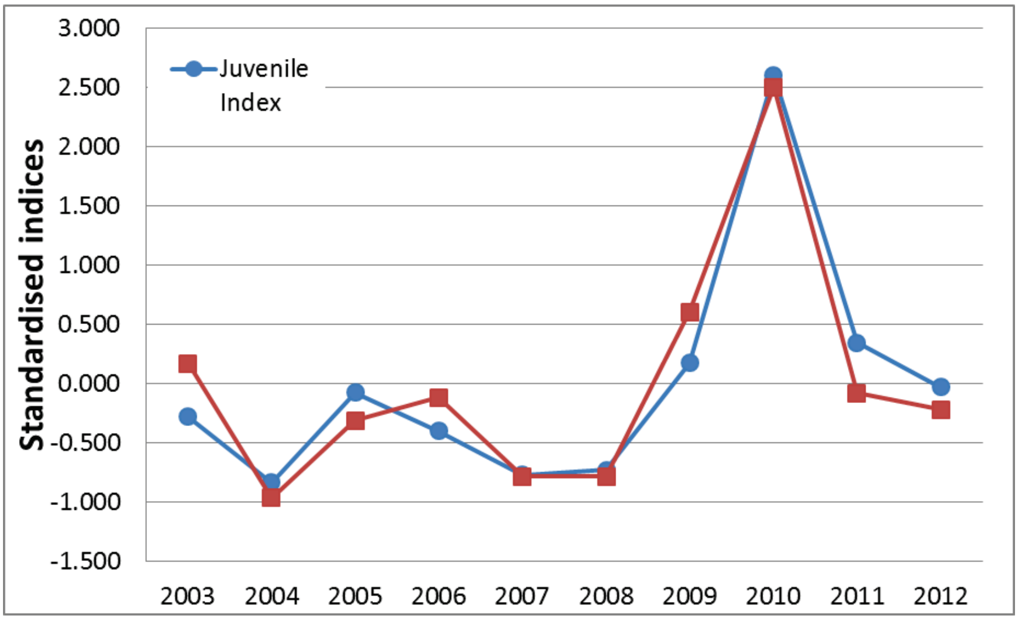


Figure 3.3.4.5: Bay of Biscay anchovy: Times series of the JUVENA anchovy juveniles abundance index (in blue) and of the recruitment (median of the age 1 biomass at the beginning of the next year) as estimated by BBM. Each of the series is standardized according to its mean and its variance.

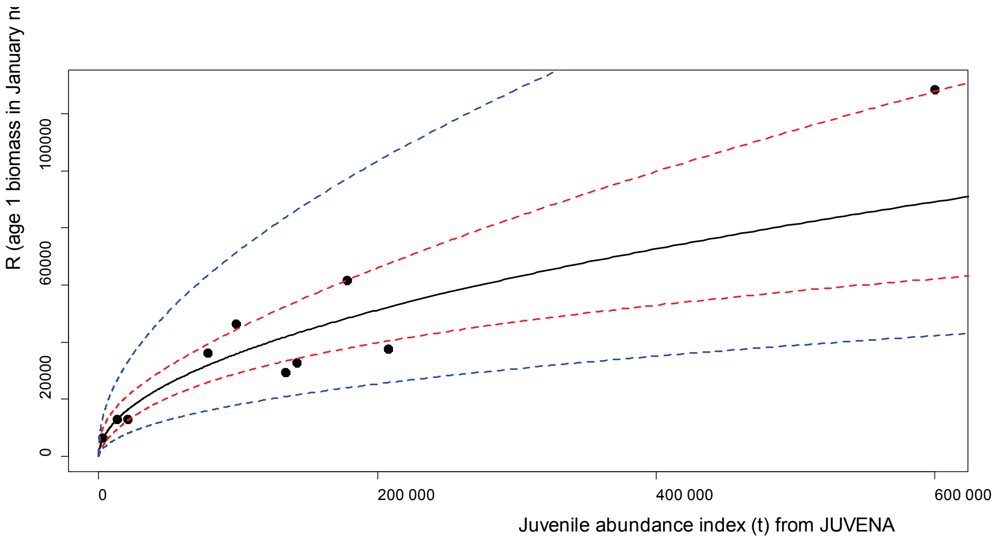


Figure 3.3.4.6: Bay of Biscay anchovy: Log linear model fitted to the recruitment (median of the age 1 biomass at the beginning of the next year, y-axis) as estimated by BBM and the juvenile abundance index from the JUVENA surveys (x-axis, in tonnes). The bullets represent the observed points from 2003 to 2012. The solid black line is the fitted model, whereas the red and blue dashed lines are the 95% confidence and prediction intervals.

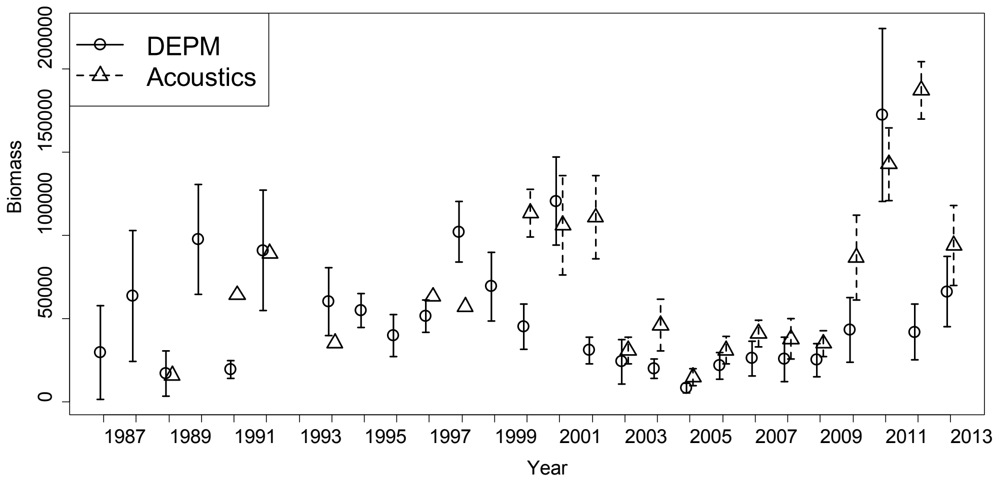


Figure 3.5.1.1: Bay of Biscay anchovy: Historical series of spawning stock biomass estimates and the corresponding confidence intervals from DEPM (solid line and circles) and acoustics (dashed line and triangles).

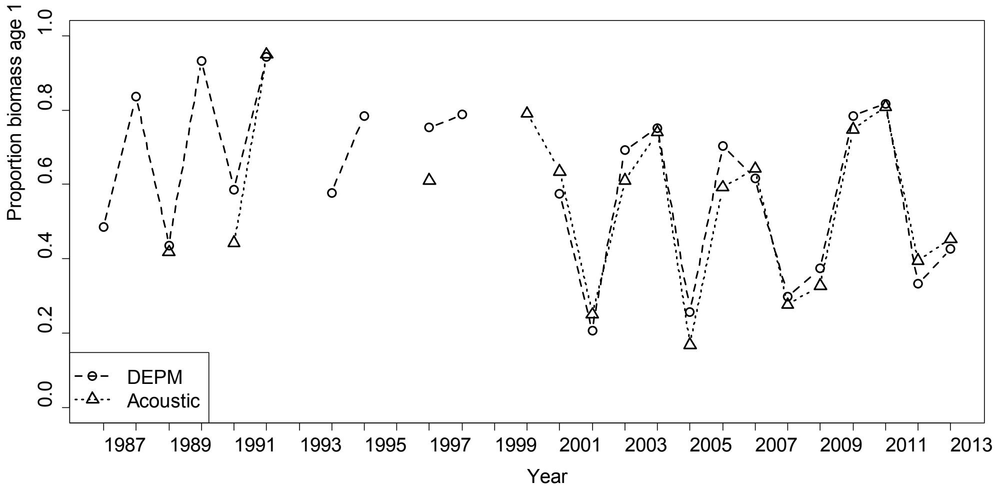


Figure 3.5.1.2: Bay of Biscay anchovy: Historical series of age 1 biomass proportion estimates from DEPM (dashed line and circles) and acoustics (dotted line and triangles).

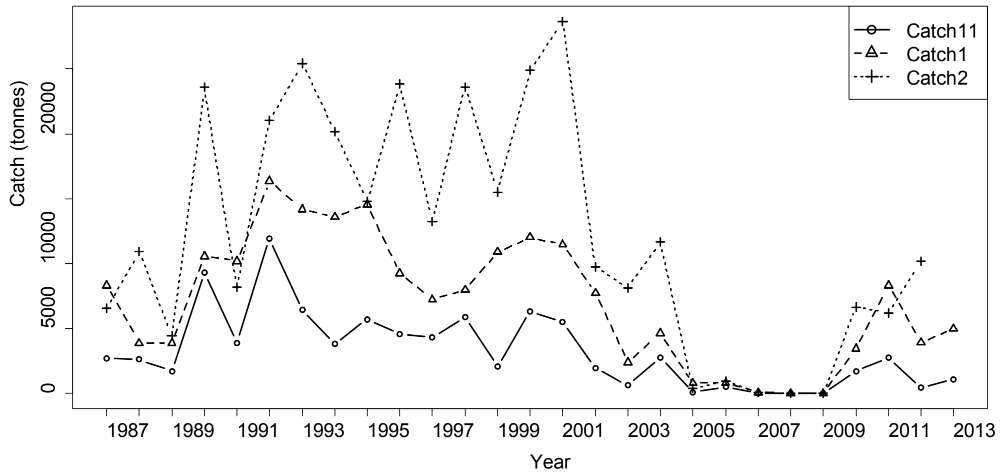


Figure 3.5.1.3: Bay of Biscay anchovy: Historical series of age 1 and total catch in the first period (1st January-15th May) (solid line and open circle and dashed line and triangle respectively) and of total catch in the second period (15th May-31st December) (dotted line and cross).

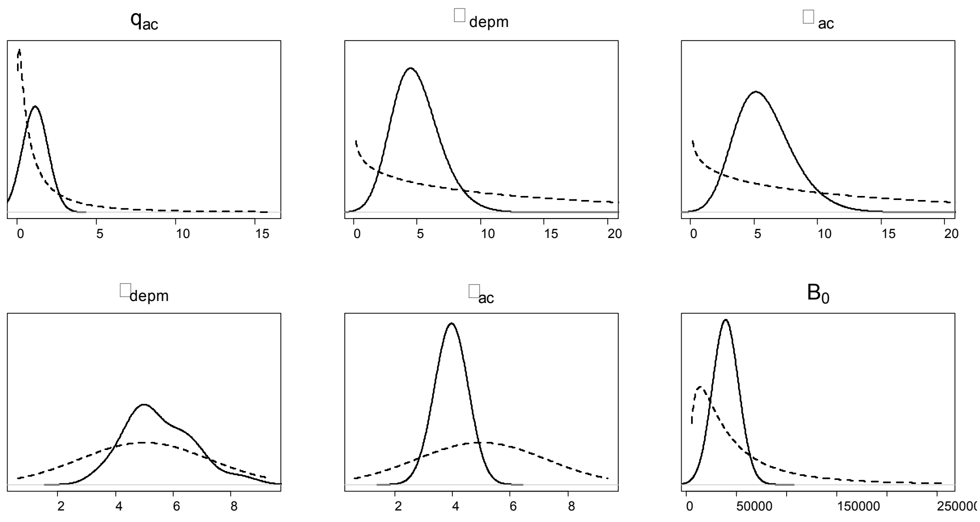


Figure 3.5.1.4: Bay of Biscay anchovy: Comparison between the prior (dotted line) and posterior distribution (solid line) for some of the parameters of BBM.

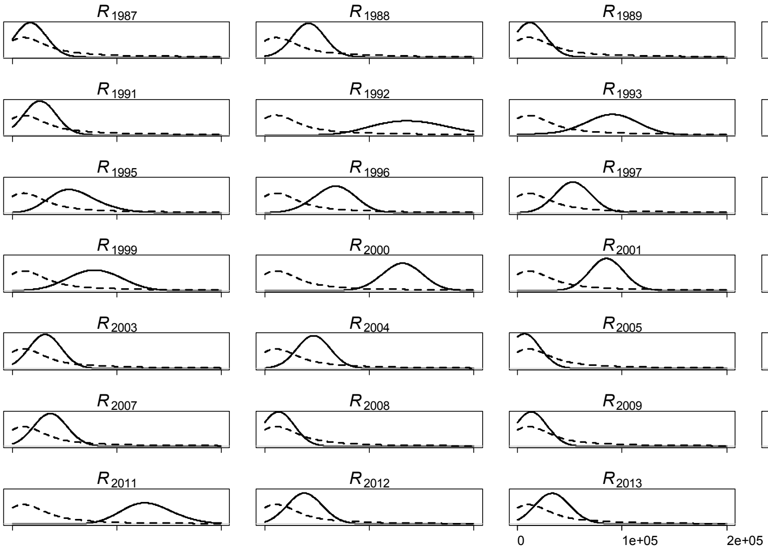


Figure 3.5.1.5: Bay of Biscay anchovy: Comparison between the prior (dotted line) and posterior distribution (solid line) for recruitment in BBM.

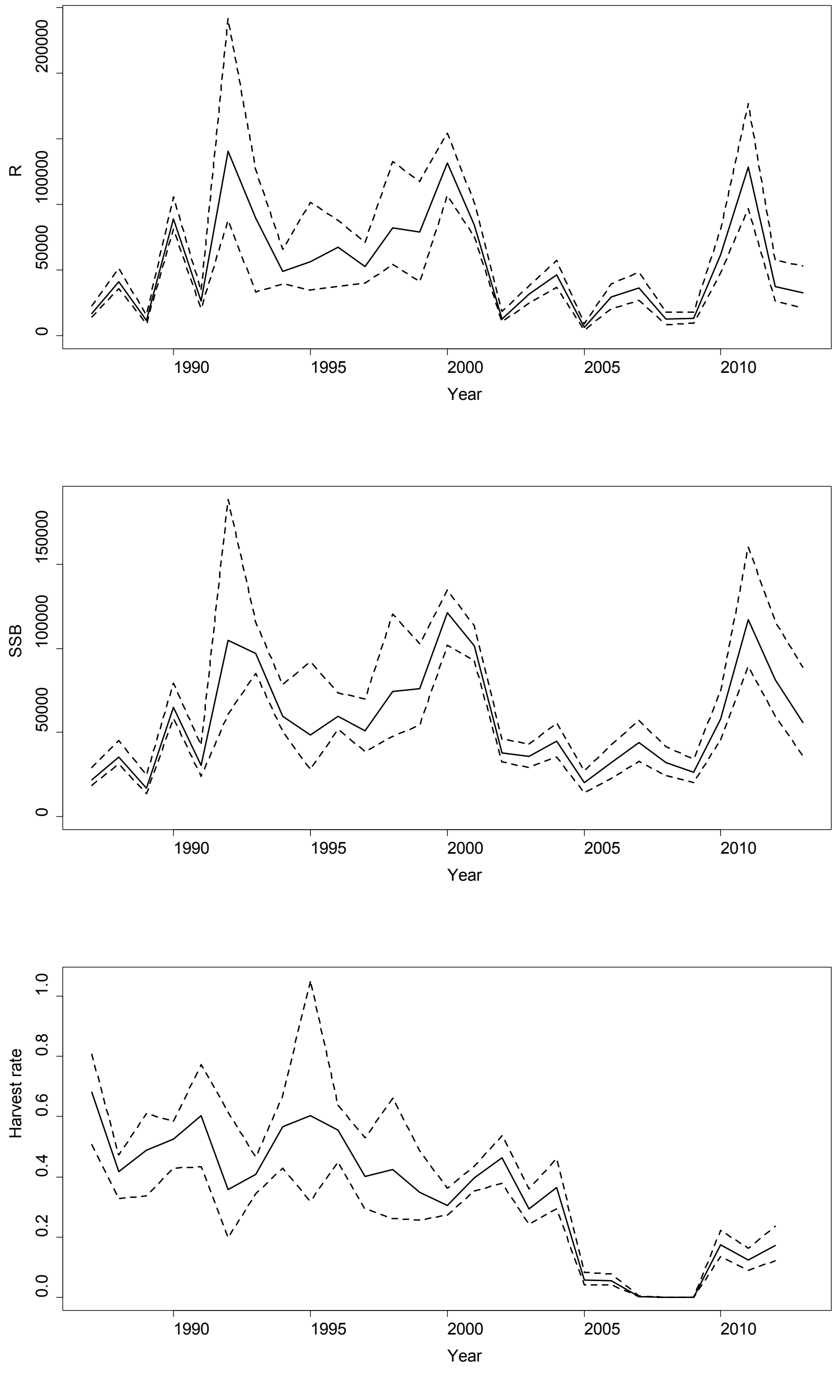


Figure 3.5.1.6: Bay of Biscay anchovy: Posterior median (solid line) and 95% probability intervals (dashed lines) for the recruitment (age 1 in mass in January), the spawning stock biomass and the harvest rates (Catch/SSB) from the BBM.

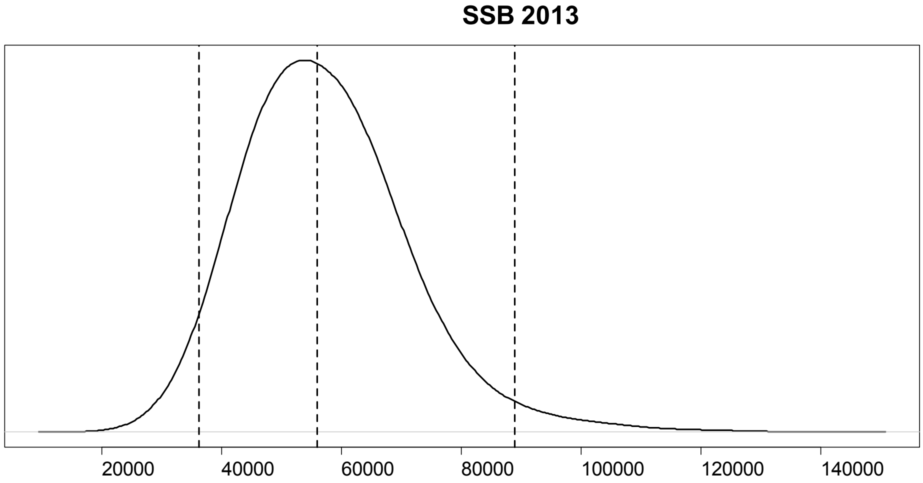


Figure 3.5.1.7: Bay of Biscay anchovy: Posterior distribution of spawning biomass in 2013 from BBM. Vertical dashed lines correspond to posterior median and 95% probability intervals.

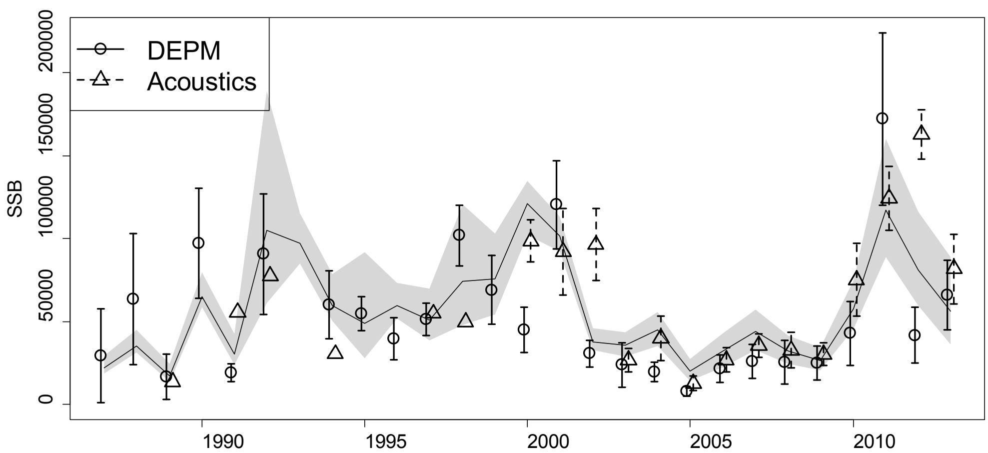


Figure 3.5.2.1: Bay of Biscay anchovy: Comparison of the SSB posterior 95% probability intervals from the BBM (grey area) and the SSB indices corrected by their catchability with the corresponding confidence intervals from DEPM (open circle and solid line) and Acoustics (triangle and dashed line).

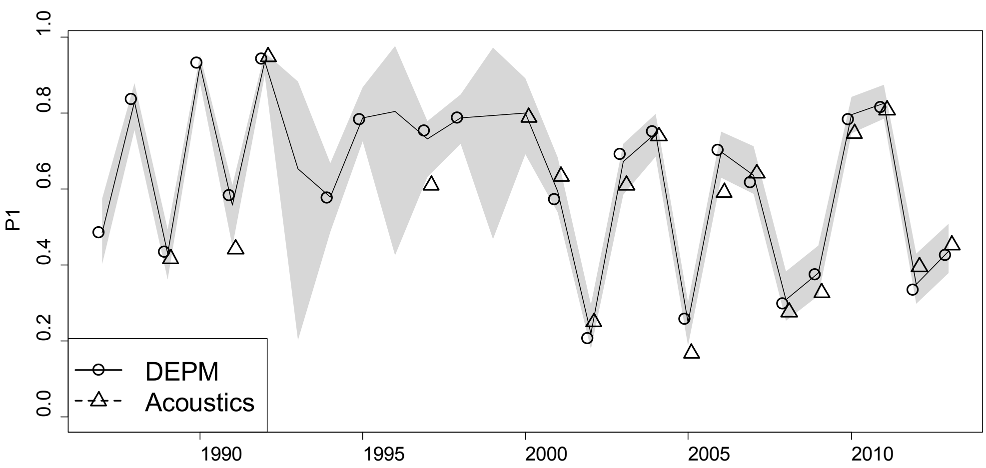


Figure 3.5.2.2: Bay of Biscay anchovy: Comparison of the age 1 biomass proportion posterior 95% probability intervals from the BBM (grey area) and the point estimates from DEPM (open circle) and Acoustics (triangle).

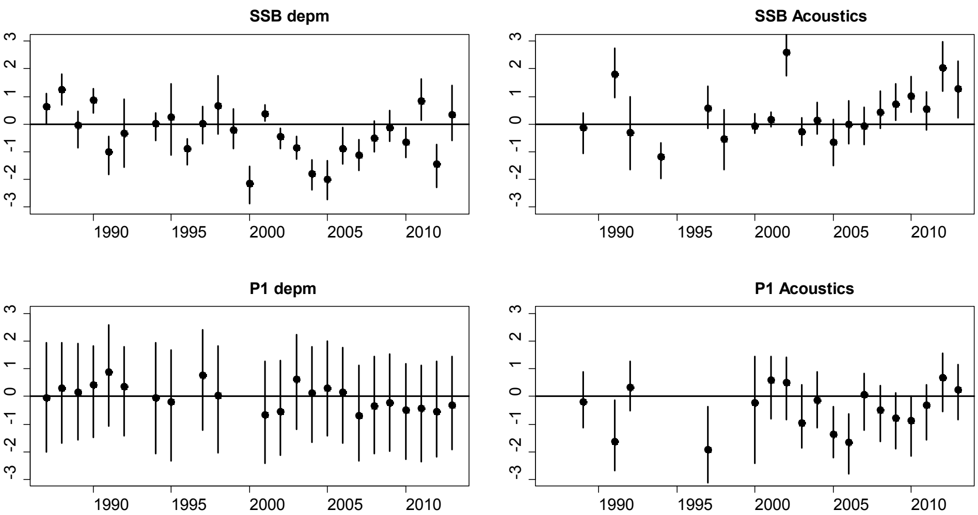


Figure 3.5.2.3: Bay of Biscay anchovy: Pearson residual medians and 95% probability intervals to the four indices used in the BBM.

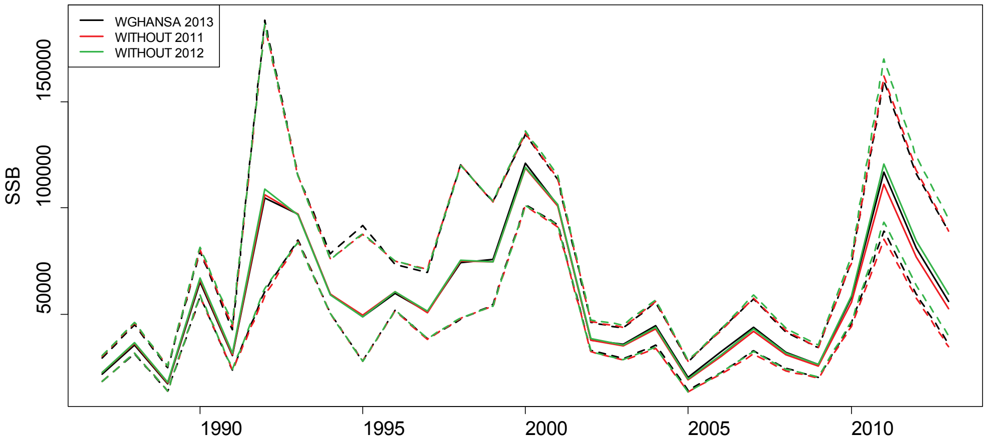


Figure 3.5.2.4: Bay of Biscay anchovy: Comparison between updated assessment (in black) in comparison with the assessments without 2011 SSB indices (in red) and without 2012 SSB indices (in green). Solid and lines represent the SSB medians and the 95% probability intervals respectively.

Figure 3.5.2.5: Bay of Biscay anchovy: Comparison between last (in red) and updated (in black) assessment. Solid and lines represent the SSB medians and the 95% probability intervals respectively.

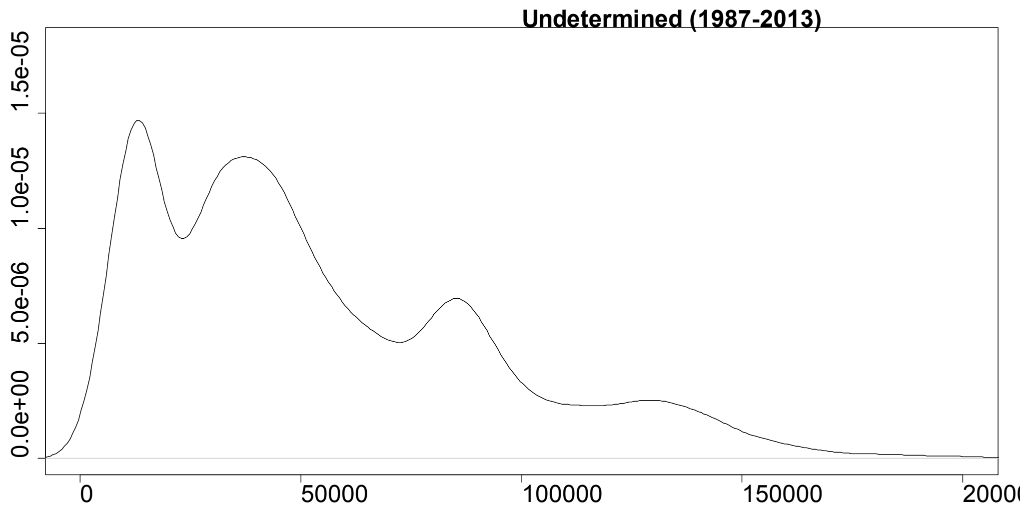


Figure 3.6.1.1: Bay of Biscay anchovy: Undetermined recruitment (age 1 mass in January) scenario for 2014.

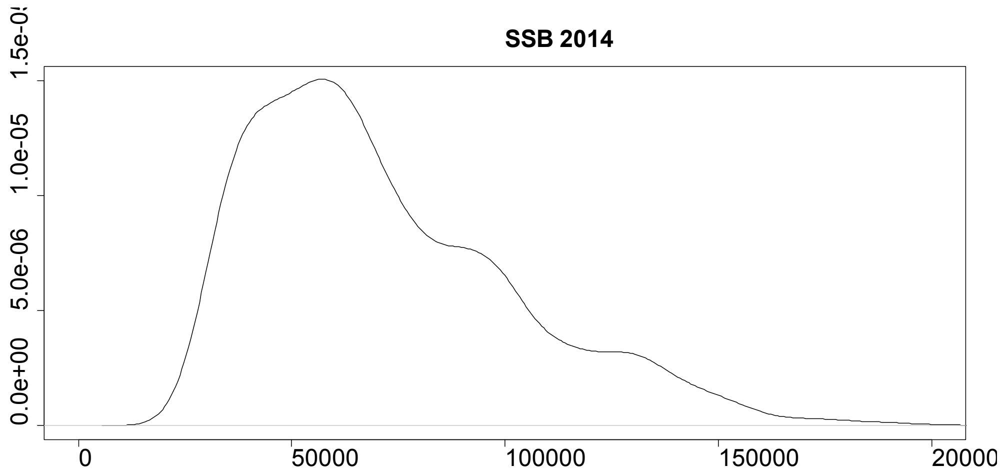


Figure 3.6.3.1: Bay of Biscay anchovy: Distribution of SSB in 2014 constructed from the posterior distribution of SSB in 2013 and the undetermined recruitment scenario in the absence of fishing.

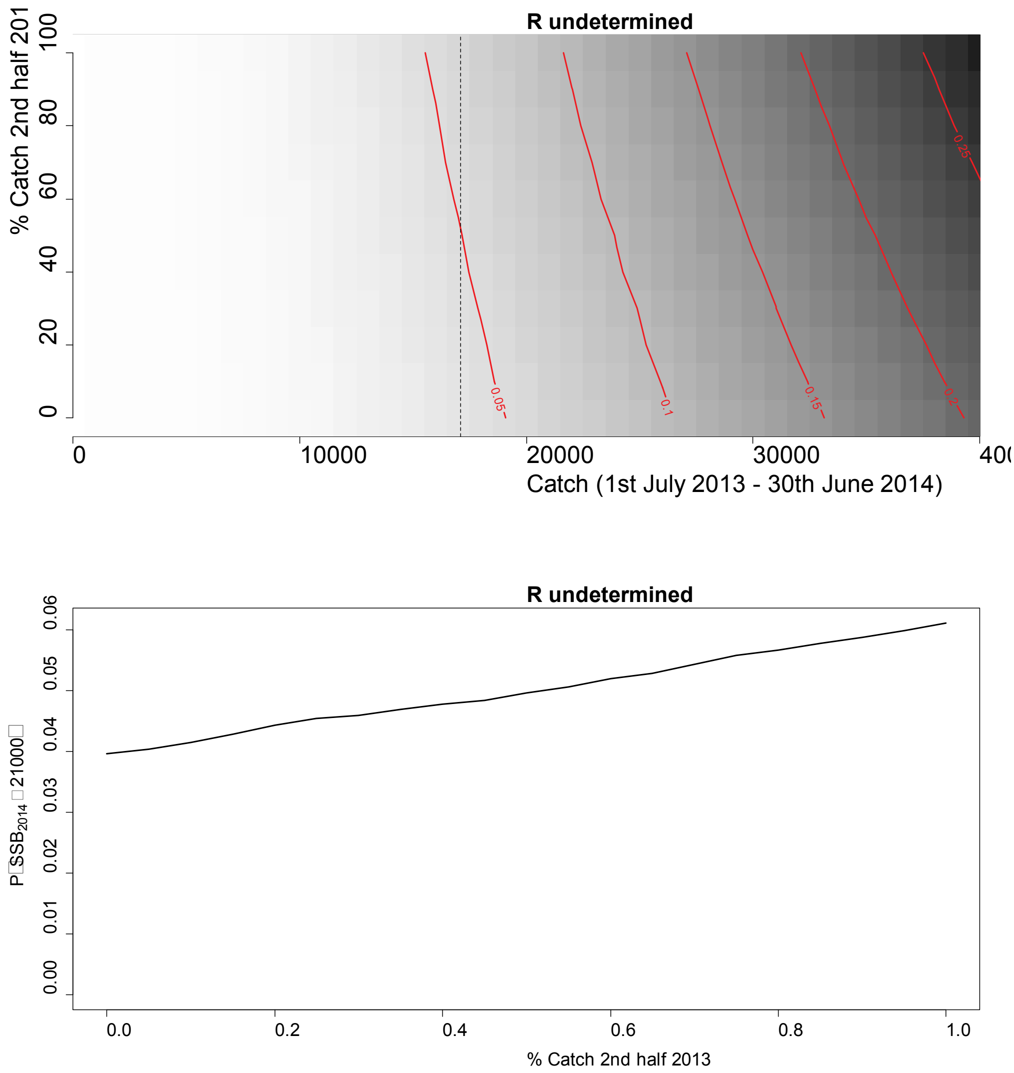


Figure 3.6.3.2: Bay of Biscay anchovy: In the top panel contour plots of probability of SSB in 2014 of falling below B_{lim} depending on the total catch from 1st July 2013 to 30th June 2014 (x-axis) and the percentage of catch corresponding to the second half of 2013 (y-axis) under the undetermined recruitment scenario (top panel). The vertical dashed line represents the TAC of 17 100 t for 2013-2014 under the long term management proposal. In the bottom panel probability of SSB in 2014 of falling below B_{lim} (y-axis) for catch levels equal to 17 100 t depending on the percentage of catch corresponding to the second half of 2013 (x-axis).

4 Anchovy in Division IXa

4.1 ACOM Advice Applicable to 2012 and 2013

ICES advice from recommendations from the ACFM in December 2005 (ICES, 2005 a) firstly stated that the state of the anchovy stock in Division IXa was unknown because of the inadequacy of the available information to evaluate the spawning stock or fishing mortality relative to risk (precautionary limits). So far, these shortcomings are still preventing from the provision of explicit management objectives for this stock and the estimation of appropriate reference points. Accordingly, ICES advice in relation to the exploitation boundaries of this stock stated in that year that catches since 2007 should be restricted to 4800 t (mean catches from the period 1988-2005, excluding 1995, 1998, 2001, and 2002, the years when catches were probably influenced by exceptionally high recruitment), and that this catch level should be maintained until the response of the stock to the fishery is known. Such an advice was repeatedly provided until 2010. Nevertheless, the agreed TAC for anchovy from 2002 to 2010 (for ICES Subareas IX and X and EC waters of the CECAF Subarea 34.1.1) was of 8000 t.

The above advice was revised in 2010 since both the most recent survey biomass index for the Portuguese acoustic survey and the disappearance of 0- group fish in the landings indicated a declining stock in the Subdivision IXa-South, where the bulk of the fishery takes place. Under the MSY approach the facts of a stock showing signs of decrease and the absence of reliable indicators for exploitation status implied that catches should be reduced from recent levels at a rate greater than the rate of stock decrease. In light of the EU policy paper on fisheries management (17 May 2010, COM(2010) 241) this stock can be classified under category 5 because it is a short lived species. However, because no advice based on a biomass escapement strategy is available, the stock was classified under category 9 because the state of the stock is not known precisely, but there were indications of a declining stock. Using the maximum 15% reduction in TAC for this category, the resulting TAC would be 6 800 t. However, TAC agreed for 2011 was set at 7600 t, with national catch quotas being established at 3635 t for Spain and 3965 t for Portugal. In any case, ACOM notes that TACs have not been restrictive to the fishery. Thus, as described in the present report, anchovy catches in Division IXa in 2011 (10 076 t) accounted for a three-fold increase in relation to the value recorded in 2010 (3013 t), after a period of three years with catch levels amongst the lowest ones recorded in the recent years.

ICES advice in 2011, based on precautionary considerations, established that catches in 2012 should be reduced. These precautionary considerations were an uncertain but decreased stock trend for anchovy in the southern area in the most recent years (2009 and 2010) and a steep increase in biomass in spring 2011 in the northern part of Division IXa, although the effect on the population for 2012 could not be predicted. For 2012 the TAC was agreed in 8360 t, with national catch quotas being established at 3998 t for Spain and 4362 t for Portugal.

ICES advice in 2012, based on the ICES approach for data limited stocks, stated that ICES could not give catch advice for 2013 because of the lack of available data on year classes that constitute the bulk of the biomass and catches (no survey indices were available at the time of the formulation of the advice). Notwithstanding the above, ICES noted that the historic fisheries and management measures seem to have been sustainable. For 2013 the TAC was agreed in 8778 t (4198 t for Spain and 4580 t for Portugal).

Given the high natural mortality experienced by this stock, its high dependence upon recruitment (the fishery depends largely on the incoming year class, the abundance of which cannot be properly estimated before it has entered the fishery), and the large inter-annual fluctuations observed in the spawning stock, ICES is aware that the state of this resource can change quickly. Therefore an in-year monitoring and management, or alternative management measures should be considered. However, such measures should take into account the data limitation on the stock and the need for a reliable index of recruitment strength.

4.2 The Fishery in 2012

4.2.1 Fishing fleets

Anchovy harvesting throughout the Division IXa is at present carried out by the following fleets:

- Portuguese purse-seine fleet.
- Portuguese polyvalent fleet (although fishing with artisanal purse-seines).
- Portuguese trawl fleet for demersal fish species.
- Spanish purse-seine fleet.

Technical characteristics of the Portuguese fleets fishing anchovy in 2012 in Division IXa are described in the sardine section of this report.

A total of 49 purse-seine vessels and 7 multipurpose vessels operated by Spain captured anchovy in the Sub-division IXa North in 2012.

Number and technical characteristics of the purse-seine vessels operated by Spain in their national waters off Gulf of Cadiz (Sub-division IXa south), differentiated between total operative fleet and fleet targeting anchovy are summarised in Table 4.2.1.1 and **Figure 4.2.1.1**. In 2012, the entire Spanish purse-seine fleet fishing in the Gulf of Cadiz was composed by 95 vessels, with 78 vessels dedicated in a greater or lesser extent to the anchovy fishing. Details of the dynamics of this fleet in terms of number of operative vessels over time in recent years are given in the Stock Annex and in previous WG reports.

4.2.2 Catches by fleet and area

4.2.2.1 Catches in Division IXa

The WG estimates of landings are shown in **Table 4.2.2.1.1**. The estimates for 2012 were considered to be identical to the official figures supplied to ICES. Therefore the WG decided to maintain the WG estimates in the subsequent reporting of catches all throughout the tables and figures.

Anchovy total landings in 2012 were 5,589 t, which represented a 44 % decrease with regard to the 2011 landings (10,076 t), but around the historical average in the recent series (**Table 4.2.2.1.1**, **Figure 4.2.2.1.1**). The contribution by each sub-division to the total catch was characterized in 2012 by a strong decrease in landings in the northernmost sub-divisions (mainly the IXa Central-North) and in the Spanish part of the Sub-division IXa-S (IXa S (Cádiz)).

As usual, the anchovy fishery in 2012 was almost exclusively harvested by purse seine fleets (99.6% of total catches; **Table 4.2.2.1.2**). However, unlike the Spanish fleet fishing in the Gulf of Cadiz, the remaining purse-seine fleets in the Division (targeting sardine and fishing anchovy as a commercial by-catch) only target anchovy when its abundance is high, as occurred in 2011.

4.2.2.2 Landings by Subdivision

The updated historical series of anchovy landings by Sub-division are shown in **Table 4.2.2.1.1** and **Figure 4.2.2.1.1**. **Table 4.2.2.1.2** shows the contribution of each fleet in the total annual landings by Sub-division. The seasonal distribution of 2012 landings by Sub-division is shown in **Table 4.2.2.2.1**.

Subdivision IXa North

Anchovy landings in 2012, 39 t, decreased notably from the 541 t recorded in 2011. Landings from this Sub-division only accounted for about 1 % of total landings in the whole Division IXa and occurred mainly during the second quarter.

Subdivision IXa Central-North

Anchovy landings in 2012 (521 t) drop down to the usual low levels observed in the recent series after the noticeable outburst (3,239 t) recorded in 2011. Landings from this Sub-division represented 9% of the total anchovy fishery in the Division. The 2012 anchovy fishery in this sub-division was concentrated in the first quarter.

Subdivision IXa Central-South

Anchovy fishery in this Sub-division in 2012 (220 t; 4% of total landings in the Division) experienced a small increase in relation to the previous year, when the fishery was almost inexistent, as it is occurring since 2005 on. The bulk of catches in 2012 were landed during the first quarter.

Subdivision IXa South

Landings in 2012 (4,810 t; 86% of the whole fishery) experienced a decrease in relation to the levels recorded in 2011 (6,294 t). As usual, the Spanish waters of the Sub-division yielded the bulk of the fishery in these southernmost areas (4,764 t). In these waters the fishery in 2012 mainly developed through the second quarter.

4.2.3 Discards

See the Stock Annex for previous available information on discards.

General guidelines on appropriate discard sampling strategies and methodologies were established during the ICES Workshop on Discard Sampling Methodology and Raising Procedures (ICES, 2003).

Data on anchovy discarding in the Spanish purse-seine fishery operating in the Gulf of Cádiz (Sub-division IXa South) are being gathered on a quarterly basis since the fourth quarter in 2009 on, within the Spanish National Sampling Scheme framed into the EC Data Collection Regulation (DCR). In 2012 a total of only 4 fishing trips (3 trips in the second quarter, 1 in the third one) were sampled for the above purpose. Anchovy discarding was almost negligible, but the low sample size makes these results not conclusive.

4.2.4 Effort and Landings per Unit Effort

Annual standardised LPUE series for the whole Spanish purse-seine fleet fishing Gulf of Cadiz anchovy (Sub-division IXa-South) are routinely provided to this WG. An updating of the available series (1988-2012) has been provided this year to this WG. Details of data availability and the standardisation process are commented in the Stock Annex. The recent dynamics of fishing effort and LPUE for this fleet has been described in previous WG reports. In the last years, it was observed a relative decrease in fishing effort which was coupled to a relative stable trend in the LPUE (at around 0.7 t/fishing day). A combination of fishing closures, both in the beginning and in the end of the year, bad weather at the start and/or the end of the fishing season, and the displacement of a part of the fleet to the Moroccan fishing grounds (under the EC-Morocco Fishery Agreement) at the same time of the re-opening of the Gulf of Cadiz fishery (usually in February), may be the causes responsible for the observed decrease in the fishing effort for the period 2008-2010. Since 2011 the EC-Morocco Fishery Agreement was not renewed and the whole fleet was again fishing in the Gulf of Cádiz probably causing the increase in the effort observed that year. The premature closure of the fishery in 2012 may be the responsible for the lower total annual effort levels exerted in the fishery. Regarding LPUE, it was suggested in previous WG reports a probable overestimation of the annual estimates computed so far because of a probable underestimation of the true exerted fishing effort on anchovy, since fishing trips targeting anchovy with zero anchovy catches are not considered in the effort measure. The available historical series of effort and LPUE estimates are shown in **Table 4.2.4.1** and **Figure 4.2.4.1**.

4.2.5 Catches by length and catches at age by Sub-division

Size composition of landings and catch-at-age data from the whole Division IXa have been routinely provided to this WG only from the Spanish Gulf of Cadiz fishery (Sub-division IXa South) since the anchovy fishery in the Division has traditionally concentrated there. Data from the Spanish fishery in Sub-division IXa North were not available since commercial landings used to be negligible. The same reason was also valid for the Portuguese sub-divisions (included the Portuguese part of the IXa South), although in this case anchovy is also a group 3 species in its national sampling program for DCF. Nevertheless, the local outbursts of anchovy in Subdivisions IXa North and Central North recorded in 2011 led to a circumstantial exploitation of the species by the fleets operating in those areas. The respective national sampling programs accounted for this event that year, although this was not the case in 2012, at least for the Portuguese fishery.

4.2.5.1 Length distributions

Subdivision IXa North

Quarterly and annual size composition of anchovy landings in the Subdivision IXa North in 2012 are shown in **Table 4.2.5.1.1** and **Figure 4.2.5.1.1**. Annual mean size in landings in 2012 was estimated at 16.0 cm.

Subdivision IXa Central-North

The size composition of 2012 anchovy landings in this Sub-division has not been provided to this WG. Length frequency distributions are only available for the third and fourth quarter in 2011. Mean lengths for each of those quarters were estimated at 14.4 cm and 16.5 cm. No clear evidences of an incoming recruitment to the fishery were detected through the second half in 2011.

Subdivision IXa Central-South

No estimates from this sub-division are available for 2012 landings.

Subdivision IXa South

Gulf of Cadiz anchovy quarterly length distributions from the Spanish fishery in 2012 are shown in **Table 4.2.5.1.2** and **Figure 4.2.5.1.2**. Length frequency distributions of Portuguese landings in the Sub-division are not available

Anchovy mean length and weight in the Spanish 2012 annual catch (11.9 cm and 12.4 g) were still amongst the highest ones ever recorded in the historical series, as it is observed since 2008, although they used to be the smallest anchovies in the Division.

4.2.5.2 Catch numbers at age

Sub-division IXa North

Quarterly and annual catch at age of anchovy in IXa North in 2012 are shown in **Table 4.2.5.2.1** and **Figure 4.2.5.2.1**. Total catch in this Sub-division in 2012 was estimated at 1.3 million fish. Landings were composed by anchovies belonging to 1, 2 and 3 age group anchovies, with 1 and 2 age-group anchovies being the dominant age groups.

Sub-division IXa Central-North

Soares *et al*. (2012) described the age reading results from anchovies collected during 2011 from research surveys and commercial samples by IPMA (with limited experience on the ageing of anchovy otoliths) as well as the results from an otolith exchange and age reading exercise with IEO (with experienced readers). Results from this exercise showed that age readings by IPIMAR were clearly improved after this exchange. Catches at age in third and fourth quarter in 2011 were provided last year to the WG (**Table 4.2.5.2.2**) and they were composed by anchovies belonging to 0, 1, 2 and 3 age groups, with 1 and 2 years old anchovies accounting for the bulk of the fishery.

Although some age readings were carried out from samples in the first quarter in 2012, no estimate of catches at age in the fishery has been provided to this WG. Such samples were composed by 1, 2 and 3 age-group anchovies, with age 1 fish being the dominant.

Subdivision IXa Central-South

No estimate from this sub-division is available.

Subdivision IXa South

Problems with ageing/reading Gulf of Cadiz anchovy otoliths were revisited in 2009 during the *Workshop on Age reading of European anchovy* (WKARA; ICES, 2010a), although such problems still persist.

The historical series of quarterly and annual catch at age of anchovy in the Spanish fishery in IXa South are shown in **Table 4.2.5.2.3** and **Figure 4.2.5.2.2**. No data are available from the Portuguese fishery in this Sub-division.

Description of annual trends of catch-at-age data from the Spanish fishery through the available data series is given in the Stock Annex.

Total catch in the Spanish fishery in 2012 was estimated at 369 million fish, which represents a 21% overall decrease in numbers with respect to 2011 (466 million).

In relation to the previous year, the aforementioned landed numbers in 2012 are the result of the relative decrease in landings of the 0 and 2 age-groups, and in a lesser extent the 1 age group. Three year old anchovies were absent in the fishery.

4.2.6 Mean length and mean weight at age in the catch

Subdivision IXa North

Annual mean length and weight at age of anchovy catches are shown in **Tables 4.2.6.1** and **4.2.6.2**, and **Figure 4.2.6.1**. Annual total mean size and weight were estimated at 16.0 cm and 30 g respectively.

Subdivision IXa Central-North

No estimates from the fishery in this sub-division in 2012 are available. Mean length and weight at age of anchovy catches for the second semester of 2011 are shown in **Tables 4.2.6.3** and **4.2.6.4.** Total mean size and weight in the second half in 2011 were estimated at 16.0 cm and 30 g respectively. Highest sizes and weights were recorded in the fourth quarter.

Sub-division IXa Central-South

No estimate from this sub-division is available.

Subdivision IXa South

Annual mean length and weight at age of Gulf of Cadiz anchovy catches are shown in **Tables 4.2.6.5** and **4.2.6.6**, and **Figure 4.2.6.2**. Anchovy mean length and weight in the Spanish 2012 annual catch were estimated at 11.9 cm and 12.4 g respectively.

Age 0 and age 1 anchovies have showed a noticeable increasing trend in both estimates in the most recent years, with the 2008-2012 estimates of mean size in landings being between the highest ones in the historical series. Conversely, from 2002 to 2010 age 2 anchovies experienced a remarkable decreasing trend in mean size and weight of landed fish, showing in 2011 a new relative increase. Three year olds were firstly recorded in the sampled landings in 1992. New occurrences of these anchovies have been observed from 2008 to 2010.

Seasonally, 0 age-group anchovies off the Gulf of Cadiz are larger (and usually also heavier) in the fourth quarter. This general pattern was apparent in 2006 – 2009 period, but it was not so in 2004 and 2005, when weights in the fourth quarter were rather similar to those estimated in the third quarter. The 1 and 2 year-old anchovies exhibit a clear and persistent pattern through the years, showing the larger mean length and heavier mean weight in the second half in the year. Three year olds occurred in a more or less constant way only through 2009. In that year, these eldest anchovies in the fishery showed larger sizes and weights between the second and fourth quarters, mainly in the second quarter.

4.3 Fishery-Independent Information

4.3.1 DEPM-based SSB estimates

BOCADEVA series

Anchovy DEPM surveys in the Division are only conducted by IEO for the SSB estimation of Gulf of Cadiz anchovy (Sub-division IXa-South, *BOCADEVA* survey series, see text table below). The methods adopted for both the conduction of these surveys and the estimation of parameters are described in the Stock Annex and in ICES (2009 a,b).

The series started in 2005 and their surveys are conducted with a triennial periodicity. The last survey in the series, *BOCADEVA 0711*, was conducted in July 2011, one month after the 2011 WGHANSA meeting. The results from this survey showed as determinant to confirm or reject the null estimate of anchovy abundance and biomass in Sub-division IXa provided by the *PELAGO 11* spring survey about 3 months before (see section 4.3.2 below). The 2011 SSB estimate was 32,757 t with a CV of 40% (**Figure 4.3.1.1**). This estimate is quite similar to the 2008 DEPM-based SSB estimate (31,527 t; CV= 32%) and indicates a rather stable adult population.

The next survey in the series will be conducted the next year. This series is not financed by DCF. **The WG recommends that this survey series is maintained to scale properly the assessment of anchovy in Sub-division IXa South**.

4.3.2 Spring/summer acoustic surveys

General

A description of the available acoustic surveys providing estimates for anchovy in Division IXa is given in the Stock Annex (see also ICES, 2007 b). Survey's methodologies deployed by the respective national Institutes (IPIMAR and IEO) are also thoroughly described in ICES (2008 c, 2009 b).

A summary list of the available acoustic and DEPM surveys providing direct estimates for anchovy in IXa is given in **Table 4.3.2.1**. **The WG considers each of these survey series as an essential tool for the direct assessment of the population in their respective survey areas (Sub-divisions) and recommends their continuity in time, mainly in those series that are suffering of interruptions through its recent history**.

Results from the Portuguese and Spanish acoustic surveys in 2012 were previously described in the last year's WGHANSA and WGACEGG reports (ICES, 2011 a, b). In 2012 only the Spanish *PELACUS 0412* survey was carried out (providing anchovy acoustic estimates for the Sub-division IXa North). Detailed information in the present section will be provided for only those surveys carried out during the elapsed time between 2012 and 2013 WGHANSA meetings.

PELACUS series

This Spanish spring acoustic survey series is the only one that samples yearly the waters off the Sub-divisions IXa-North and Sub-area VIIIc since 1984. This series is currently financed by DCF.

PELACUS 0313

PELACUS 0313 was conducted throughout March in this year and it was characterised by the occurrence of very bad weather conditions which did not allow working properly. As a consequence, most of the coastal pelagic fish community remained very close to the coast, thus not accessible to the pelagic gear samplers. This fact led to 33% of the total acoustic energy was unable to be properly allocated into fish species. **Figure 4.3.2.1** shows the distribution and species composition of valid pelagic hauls carried out during the survey.

No anchovy acoustic estimate was computed from this survey for Sub-division IXa-North although the above limitations with the acoustic detection and pelagic fishing hauls for echo-traces identification should be keep in mind.

A more detailed description of the survey is given by Riveiro *et al*. (WD 2013).

Size composition and age structure of the estimated population in IXa North during the survey series (available estimates for the period 2008-2012) were reported in the last year's report.

Table 4.3.2.2 and **Figure 4.3.2.2** describe the available anchovy acoustic estimates from this survey series for the Sub-division IXa North.

PELAGO series

The *PELAGO* survey series (spring Portuguese acoustic survey, until 2006 it was called *SAR*) is carried out every year surveying the waters of the Portuguese continental shelf and those of the Spanish Gulf of Cadiz (Sub-divisions IXa Central-North, Central-South, and South), between 20 and 200 m depth. This survey series is currently financed by DCF.

There were no *PELAGO* survey in 2012 due to the RV *Noruega* was not operative for the survey season. The *PELAGO 11* survey (see ICES, 2011 a) estimated a total biomass of 27 thousand tonnes (1,558 million fish) for the whole surveyed area, within the average value for the entire time series, but only distributed in the IXa Central-North and without no anchovy at all in the IXa Central-South and IXa South (this last sub-area is the one where the bulk of the anchovy population mainly concentrates).

During the 2011 WGACEEG meeting and last year's WGHANSA were recognised the difficulties found both in the species' identification and the realization of the pelagic hauls during the *PELAGO 11* just in the Gulf of Cádiz waters as the main causes for the probable underestimation of the anchovy population in this area. CUFES during this survey in addition pointed out to a significant amount of spawning (at a level above previous year's records of egg abundances). Therefore anchovies were spawning in the area but the acoustic couldn`t catch or see them. As described above, the results from the *BOCADEVA 0711* DEPM survey also contradicted the perception given by *PELAGO 11* of an exhausted population in the IXa South. Therefore the last year´s WGHANSA concluded that the *PELAGO 11* anchovy estimates in IXa South resulted in a strong underestimation of the actual biomass levels in the region. For this reason the estimates of *PELAGO 11* for anchovy in this area will be disregarded for the stock trend and harvest rates assessments which follow.

PELAGO 13

The *PELAGO 13* survey was conducted this year between 9th April to 14th May on board R/V Noruega. Details of the survey are given by Marques *et al*. (WD 2013). During this survey were performed 26 fishing hauls, with 8 of them being positive for anchovy (**Figure 4.3.2.3**). The species was mainly found off Cádiz and eastern Algarve coast. A small anchovy concentration was also found in the west coast, near Figueira da Foz. Total anchovy biomass in the surveyed area was estimated at 16,642 t (1,147 million fish), with 72% of this biomass being located in Sub-division IXa South (12,700 t) (**Table 4.3.2.3**; **Figures 4.3.2.4** and **4.3.2.5**). As described above, the *PELAGO 11* survey found anchovy only in the Sub-division IXa Central-North (27 thousand t). This year the biomass in this area declined to 4 thousand tonnes. Age-structured estimates have been provided to this WG (see also Marques *et al*., WD 2013). In the surveyed area were present anchovies with ages 1 to 4 years. The modal age was 1 year in the Sub-division Central-North and 2 years in both Algarve and Cádiz areas (Sub-division IXa South). However, the estimated age structure for the southern anchovies is pending of confirmation with data from the *ECOCÁDIZ 081*3 survey (in early August this year) since it contrasts with the usually derived from the fishery during the same season (second quarter).

Table 4.3.2.3 and **Figure 4.3.2.5** track the historical series of anchovy acoustic estimates from *PELAGO* surveys in the Division IXa.

Size composition and age structure of the population estimate in IXa South through the series was described in previous reports. In **Figure 4.3.2.6** we revisit the trends observed in the age structure of the population as estimated by the *PELAGO* and *ECOCÁDIZ* survey series. For *PELAGO* surveys the 2013 age-structured estimates has been excluded in that figure for the abovementioned reasons. As we described in previous reports Portuguese acoustic estimates for anchovy until this year were not provided age-structured to the WG. As an alternative, the series of age structure had been estimated by applying the Spanish Gulf of Cadiz commercial age-length keys for the second quarter in the year. It should also be taken into consideration that such keys are based on commercial samples from purse-seine catches and therefore they may result in a biased picture of the population structure because of a different catchability.

Regarding the last years in the series, the size composition of the estimated population in 2010 it was characterised by a very low number of both small and larger anchovies than in 2009, with larger anchovies than 14 cm being absent, suggesting probably a weak population structure sustaining a very low biomass level in 2010. This perception is corroborated by the age structure as estimated by the Portuguese survey, which evidences a strong decrease in 1 year old anchovies in the population, but especially in 2 year old fish.

The population age structure in previous years suggests strong 2000, (exceptionally) 2001, and 2006 year classes, with the last one still being present in 2009 (as age 3 anchovies). The strength of the 2007, 2008 and 2009 year classes decreased in relation to that observed for the 2006 year class: population numbers of age 1 anchovies in 2008, 2009 and 2010 showed 49.7%, 43.3% and 68.9% decreases in relation those ones estimated in 2007. Notwithstanding the above, the extreme situation that the population reached in spring 2011, when no anchovy was detected in the PELAGO acoustic survey, seems uncertain because the observation of high egg densities during the survey is not consistent with the null detection of biomass with acoustics.

Reasons that led to the WG to consider the 2011 acoustic estimate with caution has been commented above.

ECOCÁDIZ series

The *ECOCÁDIZ* survey series acoustically samples the shelf waters off the Sub-division IXa-South during early summer (June-July).

No *ECOCÁDIZ* survey was conducted neither in 2011 (ship time invested in the *BOCADEVA 0711* DEPM survey) nor 2012 (no ship-time available). The last estimate from this survey series dates back to 2010 (*ECOCÁDIZ 0710*). Results and estimates from this survey were shown in the 2011 WGHANSA report (ICES, 2011 a). In that same report were also described the size composition and age structure of the population in IXa South through the series (see **Figure 4.3.2.6**), including some additional comments explaining the recent trends exhibited by the acoustic estimates of anchovy in IXa-South from both the *PELAGO* and *ECOCÁDIZ* series.

Figure 4.3.2.7 and **Table 4.3.2.4** track the historical series of anchovy acoustic estimates from *ECOCÁDIZ* surveys in the Sub-division IXa South.

4.3.3 Recruitment surveys

SAR autumn survey series

The last survey in this series (aimed to cover the sardine early spawning and recruitment season in the Division IXa, but also covering the anchovy recruitment season) providing anchovy estimates was carried out in 2007 (see **Table 4.3.2.1**). **Table 4.3.2.5** shows the historical series of anchovy acoustic estimates derived from this survey series in the Division IXa available so far. The series of point estimates is at present scattered and scarce for this autumn survey series and they are not directly used in the qualitative trend-based assessment (but see **Figure 4.5.2.2** for estimates in IXa South).

ECOCÁDIZ-RECLUTAS survey series

ECOCÁDIZ-RECLUTAS 1112

ECOCÁDIZ-RECLUTAS 1112 survey is a survey conducted by the IEO for acoustically assessing the abundance of anchovy and sardine juveniles in their main recruitment areas off the Gulf of Cádiz. Details of the survey and their results are given by Ramos *et al*. (WD 2013). The survey was conducted between 10th and 27th November 2012 onboard the Spanish R/V *Emma Bardán* and its sampled area was restricted only to the Spanish waters of the Gulf of Cádiz between 10 and 200 m depth. The ten fishing operations (all of them valid) are shown in **Figure 4.3.2.8**.

Total anchovy abundance and biomass were estimated at 13,680 t and 2,649 million fish (**Table 4.3.2.6**). The resource concentrated the bulk of its effectives in the central part of the sampled area, showing a nucleus of high density in the waters of the outer shelf in front of the coasts of Chipiona-Doñana (**Figure 4.3.2.9**). The size range recorded for the species oscillated between 4.5 and 15.5 cm, with two modes, both for the abundance and the biomass estimates, at 7.5 and 10 cm (**Figure 4.3.2.10**). The smallest anchovies belonging to the first modal component (probably recruits from summer spawning events) were mainly recorded in the shallowest waters of the sector Cádiz Bay-Mazagón, where they were the dominant population fraction. A second nuclei of recruits with a larger size (around the second modal class at 10 cm), the most important in terms of abundance, was concentrated in the abovementioned high density area of the outer shelf waters in front Chipiona-Doñana, here sharing the space with one-year-old adult anchovies. The abundance and biomass of age 0 anchovies in the surveyed area were estimated at 13,354 t and 2,619 million fish, respectively, i.e. 97% and 99% of the total estimated anchovy biomass and abundance (**Figure 4.3.2.10**).

4.4 Biological Data

4.4.1 Weight at age in the stock

Weights at age in the stock are shown in **Table 4.4.1.1**. See the Stock Annex for comments on computation and trends.

4.4.2 Maturity at Age

Annual maturity ogives for Gulf of Cadiz anchovy are shown in **Table 4.4.2.1**. See the Stock Annex for comments on computation and trends in the maturity ogives of Gulf of Cádiz anchovy.

Maturity stage assignment criteria were agreed between national institutes involved in the biological study of the species during the *Workshop on Small Pelagics (Sardina pilchardus, Engraulis encrasicolus) maturity stages* (WKSPMAT; ICES, 2008 a).

4.4.3 Natural Mortality

Natural mortality is unknown for this stock. By analogy with anchovy in Sub-area VIII, natural mortality is probably high (a half-year M=0.6 has been used in previous years for the data exploration, see Stock Annex).

4.5 Assessment of the state of the stock

4.5.1 Exploration of length-based reference points

Data availability and some fishery (recent catch trajectories) and biological evidences were the basis for a previous data exploration of anchovy catch-at-age data in Sub-division IXa South (Algarve and Gulf of Cadiz) until 2009 by applying an *ad hoc* seasonal (half-year) separable model implemented and run on a spreadsheet (Ramos *et al*., 2001; ICES, 2002). Nevertheless, the exploratory assessments performed with this model were not recommended as a basis for predictions or advice due to they did not provide any reliable information about the true levels of the stock, F and Catch/SSB ratios since the assessment was not properly scaled. For the above reasons since 2009 it was preferred not to perform any exploratory assessment with this model. More details on the model settings and assumptions and its performance are described in the Stock Annex.

Upon request from the Workshop on the Development of Assessments based on life history traits and exploitation characteristics (WKLIFE), a first compilation and further exploration of available data on life-history traits (LHTs) of anchovy in Division IXa have been carried out for this WG. Length-based reference points considered here were: length (L_{mat}) at 50% maturity, von Bertalanffy growth parameters (Linf (L_∞), K, t_0), mean length at first capture (L_c, determined as the length at half of the maximum frequency in the ascending part of the curve), length where growth rate in weight is maximum (L_{opt}, where L_{opt} = 2/3 of *Linf* (L_∞)), and the theoretical length resulting from fishing with F = M ($L_{(F=M)}$, where $L_{(F=M)}$ = (3 * L_c + *Linf*)/4). With weighted mean length in the catch (L_{mean}) as indicator (computed as the mean of fish larger than L_c), several of these population characteristics can be used as reference points to infer relative exploitation and relative stock status.

Thus, as WKLIFE reported, if *Lmean* is close to *Lopt*, then either the stock is very lightly exploited, or the fishery has succeeded in using *Lopt* as a target length for sustainable fishing close to MSY. If L_{mean} is smaller than $L_{(F=M)}$, then F is likely to be larger than M. Lastly, if FMSY ≈ M, then F > FMSY. Thus, $L_{(F=M)}$ can be used as a proxy reference point for FMSY.

Anchovy LHTs have been compiled from different sources, namely, literature, own institutions' biological data bases and recent estimates based on DCF data collection. Although anchovy LHTs have been provided for anchovy in IXa North and IXa South (Cádiz), the exploratory analysis has been focused in LHTs from the later area. The analysis has been carried out with the estimated 2004-2012 pooled length frequency distribution of the Gulf of Cádiz anchovy landings in the Spanish fishery. The period under exploration corresponds to the one when a Marine Protected Area (Fishing Reserve) off the Guadalquivir River mouth was established and some others regulatory measures were implemented under a regional fishery plan which was in force during that period (see Section 4.8.2).

Results from this exercise are described in **Table 4.5.1.1** and **Figure 4.5.1.1**. Taking into account the above statements on the inferences which could be made from the length-based reference points, the resulting estimates seem to suggest that the stock is supporting in its recent history a reasonable exploitation with L_{mean} above $L_{(F=M)}$ and very close to L_{opt} and L_c=L_{mat}. Nevertheless, WG members question the validity or appropriateness of these reference points for short-lived species like anchovy (with stocks and catches supported mainly by only age group and a fishery operating around spawning time).

Trends of biomass indices in the Subdivision IXa South.

The provision of advice since 2009 has been traditionally restricted to Sub-division IXa south as this is the only area showing a persistent population and fishery. It relies in an update of the qualitative assessment carried out in 2008 and accepted by the Review Groups of the 2008 and 2009 WGANC (2008 & 2009 RGANC). This qualitative assessment is based on the joint analysis of trends showed by the available data for the Sub-division IXa South, both fishery-dependent and –independent information (*i.e.*, landings, fishing effort, cpue, survey estimates). A summary of these trends for the Sub-division IXa South is shown in the **Figure 4.5.2.2**. They indicate a relatively stable fishery and stock status with little changes until 2009, without any evidence of serious problems: the drop of landings in 2008 and 2009 was caused by a parallel fall in the fishing effort. In fact, cpue is maintained relatively stable, and survey estimates, although variable did not show marked trends until 2009. The DEPM estimates, although uncertain, matched reasonable well with acoustic estimates. The relative levels of catches to biomass indexes (taken as absolute) suggested relatively acceptable levels of harvest rates until 2009 (of about ¼ the SSB index) (see an evaluation in sections 4.5.2 and 4.7)

Since 2008 the acoustic estimates of biomass show a continuous declining trend which seems to reach an extreme situation in spring 2011, when no anchovy was detected in the *PELAGO* acoustic survey. However anchovy eggs sampled by CUFES during that survey were found at comparable or even higher levels than in the previous year 2010 during that acoustic survey, which was not consistent with the null detection of biomass with acoustics. The fishery maintained its normal activity throughout 2010 and 2011. Up to 2010 the cpue indices of the fleet did not show any declining trend, In addition, the *BOCADEVA* DEPM survey, conducted in July 2011, provided a new indication about the state of the anchovy biomass in 2011, pointing to an SSB estimate of 32,757 t: This confirmed that the reluctance of the WG to adopt the PELAGO estimate as areliable indicator in that year was correct. BOCADEVA indicated a recovery of the biomass in 2011 up to levels above the average. Unfortunately, there was no indication about the state of the anchovy biomass in spring/summer 2012 since no survey index was available. The *ECOCÁDIZ-RECLUTAS 1112* autumn survey provided a partial estimate (since only the Spanish waters were surveyed) of 13,680 t in autumn 2012, which matches well with the last spring estimate available provided later by the *PELAGO* survey in 2013 (12,700 t). Thus, landings suggest a rather stable situation for the fishery in this area; however, the most recent population estimates suggest a stock in this area somewhat below average in 2013. Results from the *ECOCÁDIZ* survey in early August this year will contribute to the perception about the state of the anchovy biomass in 2013.

Trend of biomass indices in the western Iberian shores (IXa North, Central-North and Central-South).

According to *PELAGO* survey in 2011 an outburst of anchovy biomass happened in this area, with an estimation of 27,000 t (**Figure 4.5.2.3**). This was probably due to a strong recruitment in that area (as modal lengths range between 13-15 cm). This is the highest record in biomass in this area. The second highest estimate in the area was recorded in 2008 (5,500t). A former outburst of biomass might have happened in the mid nineties, as a high record of catches appeared in 1995 (but acoustic surveys did only provide by then estimates of sardine (and not of anchovy)). The uncertainty about this phenomenon is its duration in time, as in the past these sudden outbursts have not been sustained in the following year. In fact, the anchovy population in this area has experienced a seven-fold decrease in biomass since then (4 thousand tonnes estimated in 2012), coming back to its historically usual low population levels.

Trend of biomass indices in the whole Division IXa.

Figure 4.5.2.4 shows a synoptic representation of the acoustic index from *PELAGO* and *PELACUS 04* over the total Division IXa. Over the whole Division there is a recovery of the anchovy in 2011 to the levels recorded in 2007 and 2008 and at the beginning of the series. So a perception of a fluctuating resource without a neat trend will be inferred from the figure. However, we know that such perception is erroneous as the behaviour of the population is being quite different in the different Sub-divisions of the region. This puts in doubt the stock unit of the anchovy populations inhabiting this area and the suitability of the unified management applied to the fisheries on anchovy in the different Sub-divisions of Division IXa (see management considerations about the definition of stocks in this area below).

4.5.2 Assessment of the potential fishery Harvest Rates (HR) on anchovy in Subdivision IXa South

A range of a likely potential Harvest Rates (HR) applied for the anchovy fishery in Subdivision IXa south was directly tried last year's WG through the estimation of the quotient between total Catch (tons) and Survey Biomasses for a range of potential catchability of the surveys. Given the rather consistent levels of biomass estimates provided by the acoustic and DEPM surveys applied in this area, the HR evaluation assumed equal catchability for all surveys, something coherent with the results from the assessment of anchovy in VIII, which assumes q=1 to the DEPM and estimates q=1.15 (aprox.) for the acoustic. In addition the range of catchabilities explored went from 0.6 to 1.4. The results assuming catchability =1 are shown by years in **Table 4.5.2.1**. On average for a catchability = 1 HR = 23.5% (CV of 0.4) and a maximum individual HR happens in 2002 with a HR of 39%. The sensitivity analysis for the range of selected catchabilities is shown in **Table 4.5.2.2**. If catchabilities are higher than 1, the actual Biomasses at sea would be lower and hence the HR higher than for catchabilities = 1, in proportion equal to the catchability raising factor. As such for a catchability = 1.4 the average HR would be around 33% (CV of 0.4) and the maximum individual year value would rise up to 54.2%.

In the context of the Yield per recruit analysis for Harvest rates shown in section 4.7, all the range of HR resulting from the former sensitivity analysis are well below the HR corresponding to the 50% SBR per recruit (= 0.77), thus the stock seems to be exploited sustainable. This sustainability of the current exploitation seems to be valid for any potential catchability value below 1.8.

For the western Subdivisions (IXa North to IXa Central South) a harvest ratio of about 13% in 2011 may be derived from the merged acoustic estimates in these subdivisions (28 558 t) in relation to 3 782 t of anchovy landings, a rate even at a lower level than those ones estimated in the Sub-division IXa South.

4.6 Predictions

There is no basis to predict the status of the anchovy population in 2014.

4.7 Yield per Recruit analysis and Reference Point on Harvest Rates

This section is repeated from last year report as the WG still considers this valid:

Although the current fishing pattern is uncertain, the matrix of catches at age allow to estimate the selectivities at age (relative fishing mortalities at age), which for an assumed natural mortality (M=1.2) would equal the relative catches at age (in percentages). For a given selectivity at age the Yield per recruits can be computed straightforward. This section contains a sensitivity analysis of a Yield per recruit analysis in terms of reference points for fishing mortality and Harvest rates:

Two vectors of relative catches at age were generated from the catch statistics: A first vector correspond to the average age composition in the period 1999-2011. A second vector correspond with the catches in the earlier period and 2011 (years 1996, 97, 98 and 2011) when catches at age 0 were more abundant. These two vectors are summarised in the text table below:

Mean Catches at age	Age 0	Age 1	Age 2	Age 3	Total
Mean 1999-2011	87.078	414.957	15.022	0.273	517.330
Percentage at age	16.8%	80.2%	2.9%	0.1%	
Mean 1996, 97, 98 & 2011	374.93	479.57	19.24	0.00	873.745
Percentage at age	42.9%	54.9%	2.2%	0.0%	

Mean weights at age in the catches since 1999 were used for both the catches and the population. Maturity was assumed to be knife edge like, full maturity and reproductive capacity at age 1 (as estimated to happen here at least during the recent years and consistent with the biology of the anchovy in the Bay of Biscay as well).

As the selectivities required to reproduce the relative catches at age can slightly change according to the actual level of fishing mortality (unknown) then selectivities were fitted for a vector of potential F values at age 1 (the age of reference) going from 0.2 to 1.4 in steps of 0.2. For each fitted selectivity at age a Yield per recruit analysis was made in terms of % of Spawning biomass per recruit (%SBR) for different levels of F multipliers and corresponding Harvest Rates (HR) (the quotient between catches in tonnes and Spawning Biomass). Spawning and surveying times were set to occur at the middle of the year. For the acoustic ECOCADIZ and DEPM BOCADEVA survey this is correct, as they are made in June-July, though acoustic PELAGO survey is made in March- April.

Sensitivity to the vector of natural mortality was not made, as alternative vectors would be of the type of decreasing M with Age (Gislanson *et al*. 2010) but resulting in M at age 0 and 1 probably higher than the ones considered here. Those types of vectors would imply less risk for the same relative age composition in the catches. Hence the current Y/R analysis is risk averse over other alternative vectors of Natural mortality.

The Y/R assessment was made with an Excel spread sheet, which is laid down in the software folder of the Share point. The selectivities at different F at age 1 levels were fitted with the Solver function. And the subsequent associated Y/R analysis is run with visual Basic macro in Excel.

Results for the first vector of relative catches at age are shown in T**able 4.7.1**. Sensitivity of the selectivity at age pattern to the concrete guessed level of F at age 1 for which the selectivity was fitted is minor. Thus, all reference points were rather similar across the potential alternative selectivities at age (**Table 4.7.1a**). A plot with the reference points for F and HR corresponding to the selectivity at age fitted with a presumed F at age 1 = 0.6 are shown in **Figure 4.7.1**. Not surprisingly F_0.1 is rather similar to assumed M, but F_35%(SBR) and F_50%(SBR) fall to 0.53 and 0.34. The value of F_0.1 at 1.23 will certainly be not sustainable as it corresponds with a %SBR of about 11%. In terms of Harvest Rates, HR_35%(SBR) and HR_50%(SBR) are around 1.44 and 0.78. The potential for HR to exceed 1 comes from the fact that part of the catches are made on age 0 or age 1 prior to the spawning and first observations of the cohort at survey time. For the potential range of HR assessed for this fishery (section 4.5.2), according to the selected range of potential survey catchabilities, it seems very likely that HR over the last 12 years are below HR_50%(SBR), so at sustainable levels.

For the second vector of catches at age the sensitivity analysis did not differ much from the first analysis (**table 4.7.1 b**). Results were again not much sensitive to the actual selectivity at age of the fleet matching the 43% of age 0. The value of F_0.1 was not sustainable, as it resulted in 9% of %SBR. Results in terms of Harvest rates were all rather coincident: HR_35%(SBR) and HR_50%(SBR) are around 1.5 and 0.79. As before, for the potential range of HR assessed for this fishery (section 4.5.2), according to the selected range of potential survey catchabilities, it seems very likely that HR over the last 12 years are below HR_50%(SBR), so at sustainable levels.

For both selectivities at age patters and for the levels of Harvest rates induced by the Fishery, under the assumption of a catchability equal to 1 for the surveys, the expected min, mean and max values of %SBR corresponding to those HR would be around 67%, 77% and 89% respectively. And if catchability would be equal to 1.4 then HR would be 59%, 71% and 81% respectively. Therefore, for the potential range of HR assessed for this fishery (section 4.5.2), according to the selected range of potential survey catchabilities, it seems very likely that HR over the last 12 years are below HR_50%(SBR), so at sustainable levels.

4.8 Management considerations

4.8.1 Definition of stock units

A summarised description of the distribution of the main anchovy populations in NE Atlantic European waters is given in the Stock Annex. Traditionally, the distribution of anchovy in the Division IXa has been concentrated in the Sub-division IXa South (**Figure 4.8.1.1.a**), where about 99% of the population is usually encountered during the acoustic surveys, mainly in the Spanish waters of the Gulf of Cadiz. Outside the main nucleus of the Gulf of Cadiz, resilient anchovy populations were usually detected in all fishery independent surveys (ICES, 2007 b, **Figure 4.8.1.1.b**). Occasionally large catches are produced in ICES areas IXa North and Central-North coincident with a sporadic raise up of the anchovy abundance in those areas, as for instance in 1995/96 and in 2011. The Working Group has traditionally concentrated its exploratory analysis of the anchovy in Sub-division IXa South, because it was the only persistent population in the area. The perception of the anchovy in other areas of IXa is that they are marginal populations of independent dynamics from the anchovy population in IXa South. As such the advice was based solely on the information coming from the anchovy in IXa South (Algarve and Cadiz).

In 2011 the acoustic detection of anchovy biomass by *PELAGO* spring survey in Sub-division IXa Central-North raised up from 0 t in 2010 to 27,000 t in 2011. Contrary to this, the acoustic estimates in subdivision IXa South passed from about 7,400 t in 2010 to 0 t (**Figure 4.8.1.1.c**). Beyond the noise behind these estimates, these data demonstrates the independent dynamics of the anchovy in the northern part of the IXa from the dynamics of the population in IXa south (with examples in the period 1995/96 and in 2011).

This has a direct implication: there is no firm basis to consider the anchovy in Division IXa as a single stock, given that the dynamics of the population (via their recruitment pulses) in the different areas are independent.

Recent studies by Zarraonandía (2012) on the genetic structure of the European anchovy populations using single nucleotide polymorphisms (SNP) indicate that the Gulf of Cádiz anchovy (Subdivision IXa South) is genetically different to the other samples in the Ibero-Atlantic coast, while is genetically similar to that of Alborán Sea (Spanish SW Mediterranean) (**Figure 4.8.1.2**). This genetic subdivision observed in Ibero-Atlantic coasts is in concordance with the morphological segregation pattern described by Caneco *et al*. (2004). That study suggests that the differences between areas could reflect slight adaptive reactions to small environmental differences.

From all of this it follows that there is no reason to provide a single management advice for the anchovy in all the Division IXa, given that the fishery and the exploited populations are spatially separated and with independent dynamics and different genetic structure. At the contrary, it would be better to provide separate advice for the well identified population in Sub-division IXa South, from the rest of the anchovy in the Division (occupying the western waters of the Iberian peninsula: IXa North, Central-North and Central-South). This would demand a separate management of the fisheries on anchovy in these two regions of the Division IXa.

As the last year, this issue will also be translated to the formulation of the advice this year.

4.8.2 Current management situation

No EU management plan exists for the fisheries in Division IXa.

Portuguese purse seine fishery has a fishing ban for sardine of 45 days per year since 2011, although catches of other pelagic species is permitted there is marked decline in the fishing effort.

The regulatory measures in force for the Spanish anchovy purse-seine fishing in the Division are the same as for the previous years and are summarised as follows:

Minimum landing size: 12 cm total length in VIIIc and IXa North, 10 cm in Gulf of Cadiz (IXa South).

Minimum vessel tonnage of 20 GRT with temporary exemption.

Maximum engine power: 450 h.p.

Purse-seine maximum length: 450 m.

Purse-seine maximum height: 80 m.

Minimum mesh size: 14 mm

Fishing time limited to 5 days per week, from Monday to Friday.

Cessation of fishing activities from Saturday 00:00 h to Sunday 12:00 h.

Fishing prohibition inside bays and estuaries.

In the Gulf of Cadiz (Subdivision IXa South) the Spanish purse-seine fleet was performing a voluntary closure of three months (December to February) until 1997. Since 2004 two complementary sets of management measures affecting directly to the Gulf of Cadiz fishery have been implemented and are still in force. The first one was the new "*Plan for the conservation and sustainable management of the purse-seine fishery in the Gulf of Cadiz National Fishing Ground*". This plan is in force during 12 months since October the 30th and includes a fishery closure (basically aimed to protect the anchovy recruitment) of either 45 days (between 17th of November to the 31st of December in 2004 and 2005), two months (November and December in 2006) or three months (mid November 2007 to mid February 2008, 1st December 2008 to 28th February 2009), which is accompanied by a subsidized tie-up scheme for the purse-seine fleet. The expected subsidized 3-month closure from mid-autumn in 2009 to mid-winter in 2010 was restricted to one month only, in December 2009, although the fishery was practically closed since November 2009 until February 2010 for persistent bad sea conditions during all those months. During the 2010 autumn-2011 winter the fishery was again officially closed one month, in December 2010, but the purse seine fleet did not start to fish until February 2011. The fishery was closed in the period of 2011 autumn-2012 winter in December 2011 and January 2012.

The plan also includes additional regulatory measures on the fishing effort (200 fishing days/vessel/year as a maximum) and daily catch quotas per vessel (3000 kg of sardine, 3000 kg of anchovy, 6000 kg of sardine-anchovy mixing but in no case each of these species can exceed 3000 kg). A new regulation approved in October 2006 establishes that up to 10% of the total catch weight could be constituted by fish below the established minimum landing size (10 cm) but fish must always be ≥9 cm.

Impacts of the autumn fishery closures in landings and fishing effort by the Spanish Gulf of Cadiz purse-seine fishery has been described in previous reports and, although not formally evaluated, indicate that such closures did not cause serious effects in the reduction of the exerted fishing effort, at least in the last years, but only halting the possibility of expanding even more the fishing capacity of the fleets up to the recent maxima reached in the 1999-2007 period.

The second management action in force since 15th of July 2004 in Spanish gulf of Cadiz is the delimitation of a marine protected area (fishing reserve) in the mouth and surrounding waters of the Guadalquivir river, a zone that plays a fundamental role as nursery area of fish (including anchovy) and crustacean decapods in the Gulf (**Figure 4.8.2.1**). Fishing in the reserve is only allowed (with pertinent regulatory measures) to gill-nets and trammel-nets, although in those waters outside the riverbed. Neither purse-seine nor bottom trawl fishing is allowed all over this MPA.

The effects of such closures and MPA in the Gulf of Cadiz anchovy recruitment are not still possible to be directly assessed. In any case, the implementation of both of these measures should benefit the stock.

In April 2013 Spain has implemented a new management plan for fishing vessels operating in its national fishing grounds, so it affects the purse-seine fishing in Galician (IXa North) and Gulf of Cádiz waters (IXa South (CA)). One of the main measures in this new Plan is the introduction of an individual transferable quota (ITQ) system to allocate annual national quotas. In the case of the Gulf of Cádiz purse-seine fishery this measure involves to shift from the abovementioned system of a fixed daily catch quota system for all the fleet to a new one based on the implementation of a ITQ system managed quarterly by each fishery association after resolution of the National Fishery Administration on the annual allocation of the national quota by association.

Results from the qualitative assessment described in Section 4.5 suggest that the anchovy population in the Sub-division IXa South is fluctuating population without any neat tendencies, even though it is assessed below average in 2013. Despite the likely drop of biomass in 2010 (according to the acoustic survey PELAGO), the DEPM estimates in 2011 and high levels of catches in this year suggest biomass was about normal levels in 2011. The most recent population estimates from acoustic surveys in autumn 2012 and spring 2013, although lower than average levels, don’t contradict the abovementioned perception of fluctuating stock within the historical range. According to the Harvest rate analysis exploitation seems to be sustainable. Therefore it seems that catches can be allowed to remain at current mean levels.

In the absence of any recruitment index, neither for the anchovy in subdivision IXa South nor for the populations in the remaining Sub-divisions of IXa there is sufficient information as to outline what the situation in 2014 will be.

4.8.3 Scientific advice and contributions

An in-depth evaluation of the possibilities of handling the above problems on the performance and suitability of the analytical model for the Sub-division IXa South by other kinds of assessment models was out of reach for the WGHANSA. In that context, it may be productive to consider before any benchmark process a wide range of assessment approaches in an open-minded way. It is noted that most of the signals in the data are found in the catches at age 1 in both semesters and at age 0 in the second semester, in addition to the trends in the survey biomass measurements. It might be worth exploring the time signal in these data. Production models should also be explored, but large fluctuations of the catches over time raise some doubts about the stability of the carrying capacity.

The analyses of the data should also be viewed in the context of the management strategies that might be applied. The surveys have improved greatly in recent years, both through improvements of the acoustic surveys and the initiation of a DEPM survey. In addition, recent scientific efforts have improved the understanding of the biology of the stock. As stated in previous WG, these sources of information might become the core of a knowledge base for future management, which may not necessarily need to be dependent on analytic assessments. Alternative management regimes, like harvest rate rules based on survey information, could be examined by simulations.

In order to scale the assessment, additional DEPM estimates will also be required.

4.8.4 Species interaction effects and ecosystem drivers

Anchovy is a prey species for other pelagic and demersal species, and for cetaceans and sea-birds.

The anchovy population in Subdivision IXa-South appears to be well established and relatively independent of populations in other parts of the Division. These other populations seem to be abundant only when suitable environmental conditions occur, while during unfavorable conditions they seem to be restricted to the river and "rías" estuaries (Ribeiro *et al*., 1996).

The recruitment depends strongly on environmental factors. Ruíz *et al*. (2006, 2007) evidenced the clear influence that meteorological and oceanographic factors have on the distribution of anchovy early life stages in shelf waters of the northeastern sector of the Gulf of Cadiz (IXa-South). The shallowness of the water column, the influence of the Guadalquivir River, and the local topography favor the existence of warm and chlorophyll-rich waters in the area, thus offering a favorable environment for the development of eggs and larvae. However, spring and early summer easterlies bursts may cause: a) a decrease of the water temperature by several degrees, b) generate oligotrophic conditions in the area, and c) force the offshore transport of waters over this portion of the shelf, advecting early life stages away from favorable conditions. These negative influences on the development conditions of anchovy eggs and larvae can impact on the recruitment of this species in the Gulf of Cadiz and subsequently in the anchovy fishery.

In this context, Ruíz *et al*. (2009) recently implemented the Bayesian approach for a state-space model of Gulf of Cadiz anchovy life stages. The model is used to infer 17 years (1988-2004) of stock size in the Gulf of Cadiz. Its population dynamics was modeled under the influence of the physical environment and connected to available observations of sea surface temperature, river discharge, wind, catches, catch per unit effort, and acoustic records, as available. The model diagnosed values that are consistent with independent observations of anchovy early life stages in the Gulf of Cadiz. It was also able to explain the main crises historically recorded for this fishery in the region (*e.g*., in 1995-1996).

As previously described, the Gulf of Cádiz anchovy population has also experienced a noticeable decreasing trend during the period 2008-2010 as a probable consequence of successive failures in the recruitment strength in those years (ICES, 2011). A man-induced alteration of the nursery function of the Guadalquivir estuary, caused by episodes of highly persistent turbidity events (HPTE; González-Ortegón *et al*., 2010), during the anchovy recruitment seasons in 2008, 2009 and 2010 could be one plausible explanation. Thus, the control of the Guadalquivir River flow, from a dam 110 km upstream, has an immediate effect on the estuarine salinity gradient, displacing it either seaward (reduction) or upstream (enlargement of the estuarine area used as nursery). This also affects the input of nutrients to the estuary and adjacent coastal areas. The abovementioned HPTEs used to start with strong and sudden freshwater discharges after relatively long periods of very low freshwater inflow and caused significant decreases in abundances of anchovy recruits and the mysid *Mesopodopsis slabberi*, its main prey.

All of these evidences confirm that the Gulf of Cádiz anchovy population relies on recruits to persist and, therefore, is highly vulnerable to ocean processes and totally controlled by environment fluctuations.

4.8.5 Ecosystem effects of fisheries

The purse seine fishery is highly mono-specific, with a low level of reported by-catch of non-commercial species. Information gathered from observers' at sea sampling programs and interview-based surveys indicate, at least for the western waters of the Iberian Peninsula façade, a low impact on the common dolphin population (Wise *et al*., 2007), but less data are available on seabird and turtle by-catch. Other species such as pelagic crabs are released alive and it is likely that the inflicted mortality is low.

4.9 Indicators and thresholds to trigger new advice:

Anchovy as short lived species requires updated assessment every year since the population is basically sustained by the recruited year class (at age 1), so no indicator to trigger advice is required for this species

Criteria for reopening the advice in the autumn based on summer survey: The advice provided in June every year is informed by the Spring acoustic survey PELACUS –PELAGO. Currently advice is provided splitted in two regions one for Sub Division IXa South (Cadiz and Algarve) and the other for the remainder northern areas of Division IXa. For the Sub Division IXa South, a survey every 2 out of 3 years a is carried out after the June advice; this is the summer acoustic survey ECOCADIZ. This survey could trigger revision of the split advice for this SubDivision IXa South in case of contradicting the tendencies observed by PELACUS – PELAGO in this area (as happened in 2011). A threshold level for the changes in the relative tendencies can not be established easily at this stage as it would depend on the DLS method being applied (which is not clear) and whether we are in the second of the two consecutive years or not. Ad hoc approaches should be considered according to the series available in case of perceived contradictory information.

4.10 Benchmark preparation (Tor b)

The Benchmark for anchovy in IXa foreseen for 2014, is recommended to be delayed to 2015, basically due to limited man power and to allow for the new DEPM 2014 survey to be examined by WGACEGGs in Nov2014 and serve as a new input the Benchmark.

Table 4.2.1.1. Anchovy in División IXa. Sub-division IXa South. Spanish purse-seine fleet composition in the Gulf of Cadiz (Sub-division IXa-South) in 2012. The fleet is differentiated into total fleet (left panel) and vessels targeting anchovy (right panel). The categories include both single purpose purse-seiners and trawl and artisanal vessels fishing with purse-seine in some periods through the year (multi-purpose vessels). Storage: catches are dry hold with ice (1 fishing trip equals to 1 fishing day). Similar tables for yearly data since 1999 are shown in the Stock Annex and previous WG reports.

2012	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10						
11-15	4	11	7	1		23
16-20		5	33	16		54
>20			2	13	3	18
Total	4	16	42	30	3	95

2012	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10						
11-15	2	11	7	1		21
16-20		5	29	12		46
>20			1	8	2	11
Total	2	16	37	21	2	78

Table 4.2.2.1.1. Anchovy in Division IXa. Historical series of total annual landings and by Sub-division (t). Landings in Sub-division IXa South are also differentiated between "Algarve" (A; Portuguese waters) and "Cádiz" (C; Spanish waters). Symbols legend: (-) data not available; (0) less than 1 tonne (Data from from Pestana, 1989 and 1996, and WGMHSA, WGANC, WGANSA and WGHANSA members).

Year	IXa N	IXa C-N	IXa C-S	IXa S (A)	IXa S (C)	IXa S (Total)	Total Division
1943	-	7121	355	2499	-	-	-
1944	-	1220	55	5376	-	-	-
1945	-	781	15	7983	-	-	-
1946	-	0	335	5515	-	-	-
1947	-	0	79	3313	-	-	-
1948	-	0	75	4863	-	-	-
1949	-	0	34	2684	-	-	-
1950	-	31	30	3316	-	-	-
1951	-	21	6	3567	-	-	-
1952	-	1537	1	2877	-	-	-
1953	-	1627	15	2710	-	-	-
1954	-	328	18	3573	-	-	-
1955	-	83	53	4387	-	-	-
1956	-	12	164	7722	-	-	-
1957	-	96	13	12501	-	-	-
1958	-	1858	63	1109	-	-	-
1959	-	12	1	3775	-	-	-
1960	-	990	129	8384	-	-	-
1961	-	1351	81	1060	-	-	-
1962	-	542	137	3767	-	-	-
1963	-	140	9	5565	-	-	-
1964	-	0	0	4118	-	-	-
1965	-	7	0	4452	-	-	-
1966	-	23	35	4402	-	-	-
1967	-	153	34	3631	-	-	-
1968	-	518	5	447	-	-	-
1969	-	782	10	582	-	-	-
1970	-	323	0	839	-	-	-
1971	-	257	2	67	-	-	-
1972	-	-	-	-	-	-	-
1973	-	6	0	120	-	-	-
1974	-	113	1	124	-	-	-
1975	-	8	24	340	-	-	-
1976	-	32	38	18	-	-	-
1977	-	3027	1	233	-	-	-
1978	-	640	17	354	-	-	-
1979	-	194	8	453	-	-	-
1980	-	21	24	935	-	-	-
1981	-	426	117	435	-	-	-
1982	-	48	96	512	-	-	-
1983	-	283	58	332	-	-	-
1984	-	214	94	84	-	-	-
1985	-	1893	146	83	-	-	-
1986	-	1892	194	95	-	-	-
1987	-	84	17	11	-	-	-

Table 4.2.2.1.1. (Cont'd).

Year	IXa N	IXa C-N	IXa C-S	IXa S (A)	IXa S (C)	IXa S (Total)	Total Division
1988	-	338	77	43	4263	4306	4721
1989	118	389	85	22	5330	5352	5944
1990	220	424	93	24	5726	5750	6487
1991	15	187	3	20	5697	5717	5922
1992	33	92	46	0	2995	2995	3166
1993	1	20	3	0	1960	1960	1984
1994	117	231	5	0	3035	3035	3388
1995	5329	6724	332	0	571	571	12956
1996	44	2707	13	51	1780	1831	4595
1997	63	610	8	13	4600	4613	5295
1998	371	894	153	566	8977	9543	10962
1999	413	957	96	355	5587	5942	7409
2000	10	71	61	178	2182	2360	2502
2001	27	397	19	439	8216	8655	9098
2002	21	433	90	393	7870	8262	8806
2003	23	211	67	200	4768	4968	5269
2004	4	83	139	434	5183	5617	5844
2005	4	82	6	38	4385	4423	4515
2006	15	79	15	14	4368	4381	4491
2007	4	833	7	34	5576	5610	6454
2008	5	211	87	37	3168	3204	3508
2009	19	35	5	32	2922	2954	3013
2010	179	100	2	28	2901	2929	3210
2011	541	3239	1	78	6216	6294	10076
2012	39	521	220	56	4754	4810	5589

Table 4.2.2.1.2. Anchovy in Division IXa. Catches (t) by gear and Sub-division in 1988-2012. Landings by gear in Sub-divisions IXa C-N to S (Algarve) until 2009 are not available by Sub-division.

Sub-area	Gear	1988	1989	1990	1991	1992	1993	1994	1995*	1996	1997	1998	1999	2000
IXa N	Artisanal	-	0	0	0	0	0	0	0	0	0	0	0	0
	Purse seine	-	118	220	15	33	1	117	5329	44	63	371	413	10
IXa C-N to IXa S (A)	Demersal Trawl	-	-	-	-	4	9	1	-	56	46	37	43	6
	P. seine polyvalent	-	-	-	-	1	1	3	-	94	7	35	20	7
	Purse seine	-	-	-	-	270	14	233	-	2621	579	1541	1346	297
	Not different. By gear	458	496	541	210	-	-	-	7056	-	-	-	-	-
IXa S (C)	Demersal Trawl	0	0	0	0	0	330	152	75	224	190	1148	993	104
	Purse seine	4263	5336	5911	5696	2995	1630	2884	496	1556	4410	7830	4594	2078

Sub-area	Gear	2001	2002	2003	2004	2005	2006	2007	2008	2009
IXa N	Artisanal	0	0	4	1	0	0	0	1	0,1
	Purse seine	27	21	19	2	4	15	4	4	18
IXa C-N to IXa S (A)	Demersal Trawl	16	13	7	5	7	27	14	9	4
	P. seine polyvalent	32	13	184	197	57	24	376	141	38
	Purse seine	806	888	287	455	62	57	484	185	30
	Not different. By gear	-	-	-	-	-	-	-	-	-
IXa S (C)	Demersal Trawl	36	23	14	6	0,2	0,4	0,3	0,1	0,02
	Purse seine	8180	7847	4754	5177	4385	4367	5575	3168	2922

Sub-area	Gear	2010	2011	2012
IXa N	Artisanal	4	0	1
	Purse seine	175	541	37
IXa C-N	Demersal Trawl	5	4	1
	P. seine polyvalent	45	1116	177
	Purse seine	50	2119	342
IXa C-S	Demersal Trawl	1	0,9	0.4
	P. seine polyvalent	0	0,1	17
	Purse seine	0,7	0,4	202
IXa S (A)	Demersal Trawl	8	13	16
	P. seine polyvalent	4	33	0.1
	Purse seine	17	33	41
IXa S (C)	Demersal Trawl	0	0	2
	Purse seine	2901	6216	4752

Table 4.2.2.2.1. Anchovy in Division IXa. Quarterly anchovy catches (t) by Sub-division in 2012.

SUBDIVISION	QUARTER 1		QUARTER 2		QUARTER 3		QUARTER 4		ANNUAL (2012)	
	C(t)	%	C(t)	%	C(t)	%	C(t)	%	C (t)	%
IXa North	12	31.0	18	45.8	6	15.9	3	7.3	39	0.7
IXa Central North	274	52.7	81	15.6	39	7.5	126	24.2	521	9.3
IXa Central South	190	86.3	26	12.0	0.3	0.2	3.4	1.6	220	3.9
IXa South (Algarve)	31	55.6	3	4.6	11	20.3	11	19.5	56	1.0
IXa South (Cádiz)	1127	23.7	2431	51.1	1180	24.8	16	0.3	4754	85.1
IXa South	1158	24.1	2434	50.6	1191	24.8	27	0.6	4810	86.1
TOTAL	1634	29.2	2559	45.8	1237	22.1	159	2.8	5589	100.0

Table 4.2.4.1. Anchovy in Division IXa. Sub-division IXa South. Upper panel: Standardised effort (no. of standardised fishing trips fishing anchovy). Bottom Panel: CPUE (t/fishing trip) data for Spanish fleets operating in the Gulf of Cadiz (1988-2012). Colour intensities denote increasing problems in sampling coverage of fishing effort. (SP: single purpose; MP: multipurpose; HT: heavy GRT; LT: light GRT).

	SUB-DIVISION IXa SOUTH (Gulf of Cadiz) PURSE SEINE															
FLEET	BARBATE			SANLÚCAR		P.UMBRÍA		I. CRISTINA			MEDIT.	SUBTOTAL	SUBTOTAL	TOTAL	TOTAL	OVERALL
	(SP-HT)	(SP-LT)	(MP)	(SP-LT)	(MP)	(SP-LT)	(MP)	(SP-HT)	(SP-LT)	(MP)	(SP-HT)	SP-HT	SP-LT	SP	MP	EFFORT
Year	No. fishing trips															
1988	3869	-	62	-	589	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	3869	?	3869	651	**4520**
1989	4505	-	195	-	943	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	4505	?	4505	1138	**5643**
1990	4688	-	163	-	1370	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	4688	?	4688	1533	**6221**
1991	4380	-	95	-	3178	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	4380	?	4380	3273	**7653**
1992	3918	-	194	-	1455	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	3918	?	3918	1648	**5566**
1993	2326	-	13	-	616	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	2326	?	2326	629	**2955**
1994	2140	-	115	-	1050	*n.a.*	*n.a.*	0	217	49	-	2140	217	2357	1213	**3570**
1995	1350	-	14	-	377	*n.a.*	*n.a.*	0	13	31	-	1350	13	1363	421	**1785**
1996	3406	-	104	-	1895	*n.a.*	*n.a.*	0	84	71	-	3406	84	3489	2070	**5560**
1997	2224	-	118	-	1886	*n.a.*	*n.a.*	0	76	16	-	2224	115	2339	2019	**4358**
1998	2180	82	0	2501	0	*n.a.*	*n.a.*	0	188	34	-	2180	2771	4951	34	**4985**
1999	1754	135	8	2319	0	662	584	0	282	246	-	1754	3398	5152	839	**5991**
2000	265	814	1.5	2261	0	1849	184	0	610	0	-	265	5534	5799	185	**5984**
2001	179	1040	150	1471	0	2327	51	95	1093	30	269	543	5931	6474	232	**6706**
2002	2964	586	50	1146	0	2174	13	17	458	0	126	3107	4363	7470	63	**7533**
2003	2495	433	17	1243	0	1388	0	75	714	0	0	2570	3778	6348	17	**6365**
2004	3020	524	96	775	0	1623	46	183	831	18	0	3203	3754	6956	160	**7116**
2005	2447	643	0	506	0	1235	0	170	513	0	0	2617	2897	5514	0	**5514**
2006	3167	432	0	508	0	1493	0	260	1243	0	0	3426	3676	7103	0	**7103**
2007	1651	670	13	960	0	1709	0	297	1562	0	0	1948	4901	6850	13	**6863**
2008	1316	441	0	641	0	1147	0	185	839	0	0	1501	3069	4570	0	**4570**
2009	1427	442	0	536	0	1302	0	150	781	0	0	1577	3060	4637	0	**4637**
2010	1315	437	0	554	0	1101	0	261	685	0	0	1575	2778	4353	0	**4353**
2011	1756	353	0	594	0	2018	0	327	1151	0	0	2083	4116	6199	0	**6199**
2012	1188	639	0	493	0	930	4	338	1056	10	0	1526	3119	4645	14	**4658**

	SUB-DIVISION IXa SOUTH (Gulf of Cadiz) PURSE SEINE															
FLEET	BARBATE			SANLÚCAR		P.UMBRÍA		I. CRISTINA			MEDIT.	SUBTOTAL	SUBTOTAL	TOTAL	TOTAL	OVERALL
	(SP-HT)	(SP-LT)	(MP)	(SP-LT)	(MP)	(SP-LT)	(MP)	(SP-HT)	(SP-LT)	(MP)	(SP-HT)	SP-HT	SP-LT	SP	MP	CPUE
Year	Tonnes/fishing trip															
1988	1.072	-	0.125	-	0.150	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	1.072	?	1.072	0.148	**0.938**
1989	1.116	-	0.107	-	0.234	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	1.116	?	1.116	0.212	**0.934**
1990	1.112	-	0.163	-	0.310	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	1.112	?	1.112	0.294	**0.911**
1991	1.193	-	0.142	-	0.124	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	1.193	?	1.193	0.125	**0.736**
1992	0.721	-	0.104	-	0.120	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	0.721	?	0.721	0.118	**0.543**
1993	0.590	-	0.105	-	0.094	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	0.590	?	0.590	0.094	**0.485**
1994	1.007	-	0.157	-	0.341	*n.a.*	*n.a.*	0	0.184	0.101	-	1.007	0.184	0.931	0.314	**0.722**
1995	0.148	-	0.167	-	0.166	*n.a.*	*n.a.*	0	0.084	0.014	-	0.148	0.084	0.147	0.155	**0.149**
1996	0.233	-	0.269	-	0.216	*n.a.*	*n.a.*	0	0.125	0.122	-	0.233	0.125	0.230	0.215	**0.225**
1997	1.564	-	0.299	-	0.265	*n.a.*	*n.a.*	0	0.104	0.103	-	1.564	0.131	1.494	0.266	**0.925**
1998	3.086	0.430	0	0.197	0	*n.a.*	*n.a.*	0	0.228	0.173	-	3.086	0.206	1.474	0.173	**1.465**
1999	2.147	0.269	0.237	0.225	0	0.142	0.146	0	0.156	0.157	-	2.147	0.205	0.866	0.150	**0.766**
2000	0.238	1.239	0.102	0.202	0	0.163	0.131	0	0.367	0	-	0.238	0.360	0.354	0.130	**0.347**
2001	3.379	2.284	0.892	0.225	0	0.965	0.146	2.289	1.567	0.106	2.041	2.525	1.124	1.241	0.624	**1.220**
2002	1.788	1.063	0.392	0.197	0	0.574	0.163	0.420	0.666	0	0.923	1.746	0.550	1.048	0.345	**1.042**
2003	1.371	0.637	0.152	0.307	0	0.290	0	0.542	0.322	0	0	1.347	0.341	0.749	0.152	**0.747**
2004	1.227	0.681	0.009	0.240	0	0.328	0.139	0.403	0.369	0.077	0	1.180	0.368	0.742	0.054	**0.726**
2005	1.146	0.646	0	0.497	0	0.449	0	0.605	0.503	0	0	1.110	0.511	0.795	0	**0.795**
2006	0.686	0.584	0	0.791	0	0.484	0	0.696	0.512	0	0	0.687	0.548	0.615	0	**0.615**
2007	1.214	0.955	0.029	0.759	0	0.583	0	1.122	0.557	0	0	1.200	0.660	0.814	0.029	**0.812**
2008	0.950	0.766	0	0.562	0	0.469	0	1.014	0.587	0	0	0.958	0.564	0.693	0	**0.693**
2009	0.931	0.491	0	0.951	0	0.429	0	0.321	0.334	0	0	0.873	0.505	0.630	0	**0.630**
2010	1.145	0.461	0	0.384	0	0.691	0	0.111	0.279	0	0	0.974	0.492	0.666	0	**0.666**
2011	1.437	1.022	0	0.693	0	0.789	0	1.187	0.798	0	0	1.398	0.798	0.999	0	**0.999**
2012	0.951	0.778	0	1.78	0	1.378	0.054	0.881	0.631	0.17	0	0.936	1.066	1.023	0.138	**1.020**

Table 4.2.5.1.1. Anchovy in Division IXa. Sub-division IXa North. Seasonal and annual length distributions ('000) of Spanish anchovy landings in 2012.

2012	Q1	Q2	Q3	Q4	TOTAL
Length (cm)	IXa N	IXa N	IXa N	IXa N	IXa N
3.5					
4					
4.5					
5					
5.5					
6					
6.5					
7					
7.5					
8					
8.5					
9					
9.5					
10					
10.5					
11					
11.5					
12					
12.5	8	1	0	0	8
13	0	0	0	0	0
13.5	8	1	0	0	8
14	15	5	0	0	20
14.5	0	40	18	8	66
15	60	93	24	11	189
15.5	68	183	61	28	340
16	113	147	67	31	358
16.5	38	53	18	8	117
17	31	40	12	6	88
17.5	23	20	6	3	52
18	8	7	0	0	15
18.5	8	4	0	0	11
19					
19.5					
20					
20.5					
21					
21.5					
22					
Total N	379	593	207	95	1 274
Catch (T)	12	18	6	3	39
L avg (cm)	16.1	16.0	16.0	16.0	16.0
W avg (g)	30.5	29.8	29.8	29.8	30.0

Table 4.2.5.1.2. Anchovy in Division IXa. Sub-division IXa South (Cádiz). Seasonal and annual length distributions ('000) of Spanish anchovy landings in 2012.

2012	Q1	Q2	Q3	Q4	TOTAL
Length (cm)	IXa S (C)	IXa S (C)	IXa S (C)	IXa S (C)	IXa S (C)
3.5					
4					
4.5					
5					
5.5					
6	394				394
6.5	53		11		65
7	1 813	150	80		2 042
7.5	1 967	865	320		3 153
8	4 500	3 443	1 204		9 146
8.5	9 980	6 003	2 534		18 517
9	9 901	8 297	5 318		23 516
9.5	11 582	6 637	5 069	21	23 309
10	10 978	6 903	3 191	96	21 168
10.5	7 524	7 580	1 868	350	17 321
11	9 473	9 540	870	530	20 414
11.5	10 666	15 462	790	508	27 426
12	9 440	19 129	2 168	128	30 865
12.5	14 844	24 053	4 457	97	43 451
13	8 051	24 125	8 458	28	40 663
13.5	6 215	21 306	10 381	24	37 926
14	1 428	13 965	8 652	6	24 052
14.5	516	6 107	8 611	18	15 253
15	9	1 552	5 115	10	6 685
15.5	104	930	2 316	6	3 356
16	97	178	810		1 085
16.5	1	305	489		795
17		110	29		139
17.5					
18					
18.5					
19					
19.5					
20					
20.5					
21					
21.5					
22					
Total N	119 536	176 640	72 740	1 824	370 740
Catch (T)	1 127	2 431	1 180	16	4 754
L avg (cm)	11.0	12.3	12.3	11.5	11.9
W avg (g)	9.1	13.7	14.4	8.8	12.4

Table 4.2.5.2.1. Anchovy in Division IXa. Sub-division IXa North. Spanish catch in numbers ('000) at age of anchovy on a quarterly (Q), half-year (HY) and annual basis (2011-2012).

2011	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	0	2725	0	2725	2725
	1	102	30	21636	2135	132	23771	23903
	2	148	44	2	185	192	188	380
	3	0	0	0	0	0	0	0
	Total (n)	250	74	21638	5046	324	26684	27008
	Catch (t)	5	2	444	91	7	535	541
	SOP	6	2	444	91	8	534	542
	VAR.%	84	84	100	100	84	100	100
2012	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	0	0	0	0	0
	1	186	321	110	51	507	161	668
	2	188	270	96	44	458	140	599
	3	4	3	0	0	7	0.4	7
	Total (n)	379	593	207	95	972	302	1274
	Catch (t)	12	18	6	3	30	9	39
	SOP	12	18	6	3	29	9	39
	VAR.%	103	100	99	99	101	99	100

Table 4.2.5.2.2. Anchovy in Division IXa. Sub-division IXa Central North. Portuguese catch in numbers ('000) at age of anchovy on a quarterly (Q), half-year (HY) and annual basis (only data available for the second semester in 2011).

2011	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			3516	1481		4998	
	1			6110	18949		25060	
	2			1868	17901		19769	
	3			117	0		117	
	Total (n)			11612	38331		49943	
	Catch (t)	16	262	1668	1293	278	2961	3239
	SOP			258	1249		1507	
	VAR.%			647	104		197	

Table 4.2.5.2.3. Anchovy in Division IXa. Sub-division IXa South. Spanish catch in numbers ('000) at age of Gulf of Cadiz anchovy (1995-2012) on a quarterly (Q), half-year (HY) and annual basis. Data for 1994 (not shown) and second half in 1995 estimated from an iterated ALK by applying the Kimura and Chikuni's (1987) algorithm.

1995	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	11256	23241	0	34497	34497
	1	19579	6928	6851	602	26508	7453	33961
	2	189	0	0	0	189	0	189
	3	0	0	0	0	0	0	0
	Total (n)	19769	6928	18107	23843	26697	41950	68647
	Catch (t)	185	80	148	157	265	305	571
	SOP	184	79	148	157	264	305	568
	VAR.%	101	101	100	100	101	100	100
1996	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0	0	0	413465	71074	0	484540	484540
	1	12772	130880	11550	7281	143652	18832	162483
	2	13	882	826	333	894	1159	2053
	3	0	0	0	0	0	0	0
	Total (n)	12785	131761	425842	78688	144546	504530	649076
	Catch (t)	41	807	585	348	848	933	1780
	SOP	36	743	621	306	779	926	1706
	VAR.%	114	109	94	113	109	101	104

1999	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	40549	84234	0	124784	124784
	1	249922	115218	86931	20276	365140	107207	472348
	2	10982	18701	2450	146	29683	2596	32279
	3	0	0	0	0	0	0	0
	Total (n)	260904	133919	129931	104656	394823	234587	629410
	Catch (t)	1335	1983	1582	687	3318	2269	5587
	SOP	1330	1756	1391	673	3087	2064	5150
	VAR.%	100	113	114	102	107	110	108
2000	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0	0	0	41028	77780	0	118808	118808
	1	75141	65947	46460	9949	141088	56409	197497
	2	638	2670	523	14	3307	537	3844
	3	0	0	0	0	0	0	0
	Total (n)	75779	68617	88011	87743	144395	175755	320150
	Catch (t)	329	660	655	537	989	1193	2182
	SOP	327	659	666	535	986	1201	2187
	VAR.%	101	100	98	100	100	99	100

1997	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	237283	96475	0	333758	333758
	1	67055	123878	69278	19430	190933	88708	279641
	2	22601	9828	11649	745	32429	12394	44823
	3	0	0	0	0	0	0	0
	Total (n)	89656	133706	318211	116650	223362	434860	658223
	Catch (t)	906	1110	2006	578	2016	2584	4600
	SOP	844	1273	1923	596	2117	2519	4635
	VAR.%	107	87	104	97	95	103	99

1998	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	75708	360599	0	436307	436307
	1	325407	384529	220869	84729	709936	305599	1015535
	2	11066	879	1316	0	11944	1316	13260
	3	0	0	0	0	0	0	0
	Total (n)	336473	385408	297893	445329	721881	743221	1465102
	Catch (t)	1773	2113	2514	2579	3885	5092	8977
	SOP	1923	2127	2599	2654	4050	5254	9304
	VAR.%	92	99	97	97	96	97	96

2001	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	30987	127140	0	158126	158126
	1	98687	227388	177264	37992	326075	215256	541331
	2	4155	14028	4535	624	18183	5159	23342
	3	0	0	0	0	0	0	0
	Total (n)	102842	241416	212785	165756	344258	378541	722800
	Catch (t)	924	3031	3195	1066	3955	4261	8216
	SOP	908	3014	3145	1065	3922	4210	8132
	VAR.%	102	101	102	100	101	101	101

2002	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	45129	29271	0	74399	74399
	1	218090	304295	149120	36565	522385	185685	708070
	2	2004	6083	8808	620	8087	9428	17515
	3	0	0	0	0	0	0	0
	Total (n)	220094	310378	203057	66456	530471	269512	799984
	Catch (t)	1700	2814	2566	789	4515	3355	7870
	SOP	1617	2778	2524	818	3937	3342	7737
	VAR.%	105	101	102	96	115	100	102

Table 4.2.5.2.3. (Cont'd).

2003	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	26034	45813	0	71847	71847
	1	96135	229184	49058	7028	325320	56087	381407
	2	10041	2587	481	0	12628	481	13109
	3	0	0	0	0	0	0	0
	Total (n)	106176	231772	75574	52841	337948	128415	466363
	Catch (t)	1025	2533	798	413	3557	1211	4768
	SOP	1031	2398	759	378	3430	1137	4567
	VAR.%	99	106	105	109	96	94	104

2004	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	31680	74278	0	105958	105958
	1	157200	165738	69542	6383	322937	75924	398862
	2	388	1419	248	534	1808	782	2590
	3	0	0	0	0	0	0	0
	Total (n)	157588	167157	101470	81195	324745	182665	507410
	Catch (t)	1382	1975	1192	634	3357	1826	5183
	SOP	1284	1844	1194	593	3129	1788	4916
	VAR.%	108	107	100	107	107	102	105

2007	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	41020	20672	0	61692	61692
	1	222366	230200	89173	17477	452567	106650	559217
	2	1696	5016	594	35	6712	629	7342
	3	0	0	0	0	0	0	0
	Total (n)	224063	235216	130787	38185	459279	168971	628250
	Catch (t)	1572	2233	1418	351	3806	1770	5576
	SOP	1443	2061	1290	335	3504	1624	5128
	VAR.%	109	108	110	105	109	109	109

2008	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	38173	19304	0	57477	57477
	1	38742	51510	30608	17435	90251	48043	138295
	2	10220	13400	5137	2214	23620	7351	30970
	3	245	149	0	0	394	0	394
	Total (n)	49206	65059	73918	38953	114266	112871	227137
	Catch (t)	590	1117	909	552	1707	1461	3168
	SOP	552	1056	852	518	1608	1369	2978
	VAR.%	107	106	107	107	106	107	106

2005	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	24163	13743		37906	37906
	1	195482	249404	36999	371	444886	37370	482256
	2	2716	445	334	0	3161	334	3495
	3	0	0	0	0	0	0	0
	Total (n)	198198	249848	61496	14114	448046	75610	523656
	Catch (t)	1361	2241	705	77	3602	783	4385
	SOP	1302	2098	665	67	3401	732	4132
	VAR.%	105	107	106	115	106	107	106

2006	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	9552	1751	0	11303	11303
	1	152978	296608	41515	206	449586	41721	491307
	2	2944	2317	0	0	5261	0	5261
	3	0	0	0	0	0	0	0
	Total (n)	155922	298925	51068	1957	454847	53024	507871
	Catch (t)	1289	2655	414	9	3944	424	4368
	SOP	1206	2474	387	8	3680	395	4075
	VAR.%	107	107	107	108	107	107	107

2009	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	1143	8552	0	9695	9695
	1	24402	93317	64150	3072	117719	67222	184941
	2	11236	6842	1944	28	18079	1972	20051
	3	1463	364	846	1	1827	846	2673
	Total (n)	37101	100523	68084	11652	137624	79736	217360
	Catch (t)	530	1279	1006	107	1809	1113	2922
	SOP	486	1194	937	100	1680	1037	2717
	VAR.%	109	107	107	107	108	107	108

2010	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	16924	17538	0	34462	34462
	1	6154	148182	46697	9351	154336	56048	210384
	2	144	5690	5285	0	5833	5285	11118
	3	0	102	155	0	102	155	257
	Total (n)	6297	153973	69061	26889	160271	95950	256221
	Catch (t)	67	1698	907	229	1765	1136	2901
	SOP	60	1664	907	229	1724	1136	2859
	VAR.%	112	102	100	100	102	100	102

Table 4.2.5.2.3. (Cont'd).

2011	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	26034	45813	0	71847	71847
	1	96135	229184	49058	7028	325320	56087	381407
	2	10041	2587	481	0	12628	481	13109
	3	0	0	0	0	0	0	0
	Total (n)	106176	231772	75574	52841	337948	128415	466363
	Catch (t)	1025	2533	798	413	3557	1211	4768
	SOP	1031	2398	759	378	3430	1137	4567
	VAR.%	99	106	105	109	96	94	104
2012	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	23500	1765	0	25265	25265
	1	116963	172327	46139	58	289290	46197	335487
	2	2573	4313	1461	1	6887	1462	8348
	3	0	0	0	0	0	0	0
	Total (n)	119536	176640	71101	1824	296176	72924	369100
	Catch (t)	1127	2431	1208	16	3558	1224	4782
	SOP	1089	2423	1027	15972	3512	1043	4555
	VAR.%	103	100	118	101	101	117	105

Table 4.2.6.1. Anchovy in Division IXa. Sub-division IXa North. Mean length (TL, in cm) at age in the Spanish catches of anchovy on a quarterly (Q), half-year (HY) and annual basis (2011-2012).

2011	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0				12,6		12,6	12,6
	1	14,3	14,3	15,1	16,3	14,3	15,2	15,2
	2	15,8	15,8	17,3	16,5	15,8	16,5	16,2
	3							
	Total	15,2	15,2	15,1	14,3	15,2	15,0	15,0
2012	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0							
	1	15.4	15.6	15.7	15.7	15.5	15.7	15.6
	2	16.7	16.5	16.3	16.3	16.6	16.3	16.5
	3	18.5	18.3	17.8	17.8	18.4	17.8	18.4
	Total	16.1	16.0	16.0	16.0	16.0	16.0	16.0

Table 4.2.6.2. Anchovy in Division IXa. Sub-division IXa North. Mean weight (in kg) at age in the Spanish catches of anchovy on a quarterly (Q), half-year (HY) and annual basis (2001-2012).

2011	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0				0,010		0,010	0,010
	1	0,020	0,020	0,020	0,027	0,020	0,021	0,021
	2	0,028	0,028	0,033	0,028	0,028	0,028	0,028
	3							
	Total	0,025	0,025	0,020	0,018	0,025	0,020	0,020
2012	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0							
	1	0.027	0.027	0.028	0.028	0.027	0.028	0.027
	2	0.034	0.033	0.032	0.032	0.033	0.032	0.033
	3	0.047	0.046	0.043	0.043	0.046	0.043	0.046
	Total	0.031	0.030	0.030	0.030	0.030	0.030	0.030

Table 4.2.6.3. Anchovy in Division IXa. Sub-division IXa Central North. Mean length (TL, in cm) at age in the Portuguese catches of anchovy on a quarterly (Q), half-year (HY) and annual basis (only data available for the second semester in 2011).

2011	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			13,8	15,8		14,4	
	1			14,4	16,3		15,8	
	2			15,4	16,7		16,5	
	3			15,4			15,4	
	Total			14,4	16,5		16,0	

Table 4.2.6.4. Anchovy in Division IXa. Sub-division IXa Central North. Mean weight (in kg) at age in the Portuguese catches of anchovy on a quarterly (Q), half-year (HY) and annual basis (only data available for the second semester in 2011).

2011	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,019	0,029		0,022	
	1			0,022	0,032		0,029	
	2			0,028	0,034		0,033	
	3			0,028			0,028	
	Total			0,022	0,033		0,030	

Table 4.2.6.5. Anchovy in Division IXa. Sub-division IXa South. Mean length (TL, in cm) at age in the Spanish catches of Gulf of Cadiz anchovy (1995-2012) on a quarterly (Q), half-year (HY) and annual basis. Data for 1994 (not shown) and second half in 1995 estimated from an iterated ALK by applying the Kimura and Chikuni's (1987) algorithm. Data from 1988 to 1994 has been previously reported in WGMHSA reports.

1995	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			10,3	10,2		10,2	10,2
	1	11,3	11,8	11,4	13,0	11,5	11,6	11,5
	2	14,7				14,7		14,7
	3							
	Total	11,4	11,8	10,7	10,2	11,5	10,4	10,9

1996	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			5,6	7,3		5,8	5,8
	1	7,4	8,5	12,9	13,7	8,4	13,2	8,9
	2	14,0	13,9	15,2	15,6	13,9	15,3	14,7
	3							
	Total	7,4	8,5	5,8	7,9	8,4	6,1	6,6

1997	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			7,1	8,1		7,4	7,4
	1	10,0	10,5	13,1	13,0	10,3	13,0	11,2
	2	13,4	14,0	15,0	15,1	13,6	15,0	14,0
	3							
	Total	10,9	10,8	8,7	8,9	10,8	8,8	9,5

1998	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			7,1	8,8		8,5	8,5
	1	9,5	9,2	11,9	12,2	9,3	12,0	10,1
	2	13,2	14,0	15,0		13,3	15,0	13,5
	3							
	Total	9,6	9,2	10,7	9,5	9,4	10,0	9,7

1999	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			7,7	9,3		8,8	8,8
	1	8,2	12,2	12,7	12,5	9,5	12,7	10,2
	2	13,4	14,1	15,2	14,9	13,8	15,2	13,9
	3							
	Total	8,4	12,5	11,2	10,0	9,8	10,6	10,1

2000	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			7,7	9,5		8,9	8,9
	1	8,2	10,9	11,9	12,5	9,4	12,0	10,2
	2	14,1	15,0	15,4	16,1	14,9	15,5	15,0
	3							
	Total	8,2	11,1	10,0	9,8	9,6	9,9	9,8

2001	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			9,9	8,4		8,7	8,7
	1	10,7	11,4	13,2	13,0	11,2	13,1	12,0
	2	15,5	16,2	16,3	16,2	16,0	16,3	16,1
	3							
	Total	10,9	11,7	12,8	9,5	11,4	11,3	11,4

2002	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			7,9	10,2		8,8	8,8
	1	10,7	10,6	12,8	13,6	10,6	12,9	11,2
	2	15,0	15,1	15,6	15,7	15,1	15,6	15,4
	3							
	Total	10,7	10,7	11,8	12,1	10,7	11,9	11,1

2003	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			9,6	10,1		9,9	9,9
	1	10,8	11,3	12,1	12,6	11,1	12,2	11,3
	2	15,1	15,4	16,5		15,1	16,5	15,2
	3							
	Total	11,2	11,3	11,3	10,4	11,3	10,9	11,2

2004	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			9,9	10,1		10,0	10,0
	1	10,9	11,8	12,7	13,3	11,4	12,8	11,6
	2	15,8	14,5	15,9	15,2	14,8	15,4	15,0
	3							
	Total	10,9	11,8	11,8	10,4	11,4	11,2	11,3

Table 4.2.6.5. (Cont'd).

2005	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			9,0	9,4		9,1	9,1
	1	10,1	10,8	12,7	11,8	10,5	12,7	10,7
	2	13,9	14,3	15,2		14,0	15,2	14,1
	3							
	Total	10,2	10,8	11,3	9,4	10,5	10,9	10,6

2006	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			8,6	9,1		8,7	8,7
	1	10,7	10,8	11,1	10,2	10,8	11,1	10,8
	2	13,5	14,8			14,1		14,1
	3							
	Total	10,8	10,9	10,6	9,2	10,8	10,6	10,8

2007	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			9,5	10,4		9,8	9,8
	1	10,2	10,6	12,1	12,1	10,4	12,1	10,7
	2	13,2	14,3	14,7	14,4	14,0	14,7	14,1
	3							
	Total	10,2	10,7	11,3	11,2	10,5	11,3	10,7

2008	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			10,3	11,3		10,6	10,6
	1	11,2	12,7	13,1	13,7	12,1	13,3	12,5
	2	13,8	14,6	14,5	14,5	14,2	14,5	14,3
	3	15,7	14,9			15,4		15,4
	Total	11,8	13,1	11,7	12,6	12,5	12,0	12,3

2009	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			8,5	10,4		10,2	10,2
	1	12,3	11,7	12,6	12,0	11,8	12,6	12,1
	2	13,5	14,1	14,4	14,4	13,8	14,4	13,8
	3	14,6	15,3	15,2	15,5	14,7	15,2	14,9
	Total	12,7	11,9	12,6	10,8	12,1	12,3	12,2

2010	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			10,2	10,7		10,5	10,5
	1	11,4	11,6	13,1	12,3	11,6	12,9	12,0
	2	14,4	13,9	14,1		13,9	14,1	14,0
	3		14,8	15,4		14,8	15,4	15,2
	Total	11,5	11,7	12,5	11,3	11,7	12,1	11,8

2011	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			10,7	11,3		10,9	10,9
	1	11,3	11,8	12,1	13,8	11,6	12,2	11,7
	2	14,8	13,8	15,3	13,8	14,7	15,3	15,1
	3							
	Total	11,4	11,8	11,3	11,4	11,6	11,3	11,5

2012	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			10.2	11.4	0	10.3	10.3
	1	11.0	12.2	13.3	14.1	11.7	13.3	11.9
	2	12.8	14.4	14.6	14.3	13.8	14.6	13.9
	3							
	Total	11.0	12.3	12.3	11.5	11.8	12.3	11.9

Table 4.2.6.6. Anchovy in Division IXa. Sub-division IXa South. Mean weight (in kg) at age in the Spanish catches of Gulf of Cadiz anchovy (1995-2012) on a quarterly (Q), half-year (HY) and annual basis. Data for 1994 (not shown) and second half in 1995 estimated from an iterated ALK by applying the Kimura and Chikuni's (1987) algorithm. Data from 1988 to 1994 has been previously reported in WGMHSA reports.

1995	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,007	0,006		0,007	0,007
	1	0,009	0,011	0,010	0,014	0,010	0,010	0,010
	2	0,021				0,021		0,021
	3							
	Total	0,009	0,011	0,008	0,007	0,010	0,007	0,008

1996	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,001	0,003		0,001	0,001
	1	0,003	0,006	0,014	0,015	0,005	0,015	0,006
	2	0,018	0,017	0,023	0,023	0,017	0,023	0,020
	3							
	Total	0,003	0,006	0,001	0,004	0,005	0,002	0,003

1997	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,003	0,003		0,003	0,003
	1	0,007	0,009	0,015	0,013	0,008	0,015	0,010
	2	0,016	0,019	0,023	0,021	0,017	0,023	0,018
	3							
	Total	0,009	0,010	0,006	0,005	0,009	0,006	0,007

1998	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,003	0,005		0,004	0,004
	1	0,005	0,005	0,011	0,011	0,005	0,011	0,007
	2	0,014	0,019	0,022		0,014	0,022	0,015
	3							
	Total	0,006	0,006	0,009	0,006	0,006	0,007	0,006

1999	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,003	0,005		0,005	0,004
	1	0,005	0,012	0,014	0,012	0,007	0,013	0,008
	2	0,015	0,020	0,023	0,020	0,018	0,023	0,018
	3							
	Total	0,005	0,013	0,011	0,006	0,008	0,009	0,008

2000	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,003	0,005		0,005	0,005
	1	0,004	0,009	0,011	0,012	0,006	0,011	0,008
	2	0,018	0,024	0,025	0,027	0,023	0,025	0,023
	3							
	Total	0,004	0,010	0,008	0,006	0,007	0,007	0,007

2001	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,006	0,004		0,005	0,005
	1	0,008	0,011	0,016	0,014	0,010	0,015	0,012
	2	0,025	0,032	0,031	0,028	0,030	0,031	0,030
	3							
	Total	0,009	0,012	0,015	0,006	0,011	0,011	0,011

2002	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,003	0,007		0,005	0,005
	1	0,007	0,009	0,014	0,016	0,008	0,015	0,010
	2	0,019	0,025	0,027	0,026	0,024	0,027	0,025
	3							
	Total	0,007	0,009	0,012	0,012	0,008	0,012	0,010

2003	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,006	0,006		0,006	0,006
	1	0,008	0,010	0,012	0,012	0,010	0,012	0,010
	2	0,022	0,026	0,030		0,023	0,030	0,023
	3							
	Total	0,010	0,010	0,010	0,007	0,010	0,009	0,010

2004	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,007	0,007		0,007	0,007
	1	0,008	0,011	0,014	0,015	0,010	0,014	0,010
	2	0,026	0,021	0,028	0,023	0,022	0,024	0,023
	3							
	Total	0,008	0,011	0,012	0,007	0,010	0,010	0,010

Table 4.2.6.6. (Cont'd).

2005	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,005	0,005		0,005	0,005
	1	0,006	0,008	0,015	0,009	0,008	0,008	0,008
	2	0,017	0,021	0,025		0,018	0,019	0,019
	3							
	Total	0,007	0,008	0,011	0,005	0,008	0,010	0,008

2006	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,004	0,004		0,004	0,004
	1	0,008	0,008	0,008	0,006	0,008	0,008	0,008
	2	0,015	0,021			0,017		0,017
	3							
	Total	0,008	0,008	0,008	0,004	0,008	0,007	0,008

2007	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,005	0,007		0,006	0,006
	1	0,006	0,009	0,012	0,011	0,007	0,012	0,008
	2	0,015	0,020	0,022	0,018	0,019	0,021	0,019
	3							
	Total	0,006	0,009	0,010	0,009	0,008	0,010	0,008

2008	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,007	0,009		0,008	0,008
	1	0,009	0,015	0,015	0,017	0,012	0,016	0,014
	2	0,018	0,022	0,021	0,021	0,020	0,021	0,020
	3	0,027	0,023			0,026		0,026
	Total	0,011	0,016	0,012	0,013	0,014	0,012	0,013

2009	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,004	0,008		0,007	0,007
	1	0,012	0,011	0,014	0,011	0,011	0,014	0,012
	2	0,015	0,020	0,020	0,019	0,017	0,020	0,018
	3	0,019	0,026	0,023	0,023	0,021	0,023	0,022
	Total	0,013	0,012	0,014	0,009	0,012	0,013	0,012

2010	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	0,007	0,007		0,007	0,007
	1	0,009	0,010	0,015	0,011	0,010	0,014	0,011
	2	0,019	0,019	0,019		0,019	0,019	0,019
	3		0,022	0,025		0,022	0,025	0,024
	Total	0,009	0,011	0,013	0,009	0,011	0,012	0,011

2011	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,008	0,009		0,008	0,008
	1	0,009	0,011	0,011	0,017	0,010	0,012	0,010
	2	0,022	0,017	0,023	0,017	0,021	0,023	0,023
	3							
	Total	0,010	0,011	0,010	0,010	0,010	0,010	0,010

2012	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0.008	0.009		0.008	0.008
	1	0.009	0.014	0.017	0.017	0.012	0.017	0.012
	2	0.014	0.022	0.023	0.017	0.019	0.023	0.020
	3							
	Total	0.009	0.014	0.014	0.009	0.012	0.014	0.012

Table 4.3.2.1. Acoustic and DEPM surveys providing direct estimates for anchovy in Division IXa. (1): surveys used until 2008 as tuning series in the exploratory analytical assessment of anchovy in Sub-division IXa South (Algarve and Gulf of Cádiz) (see Section 4.5.1); (2): surveys used since 2008 in the trends-based qualitative assessment; (3): *ECOCÁDIZ-COSTA 0709*, (pilot) Spanish survey surveying shallow waters <20 m depth and complementary to the standard survey; ((Month)): surveys that were carried out but did not provide any Gulf of Cádiz anchovy acoustic estimate because of its very low presence and/or for an incomplete geographical coverage (some areas were not covered: either the Spanish or the Portuguese part of the Gulf).

Method	Acoustics							DEPM	
Survey	PELACUS 04	PELAGO		SAR	ECOCÁDIZ		ECOCÁDIZ-RECLUTAS	BOCADEVA	
Institute (Country)	IEO (Spain)	IPIMAR (Portugal)		IPIMAR (Portugal)	IEO (Spain)		IEO (Spain)	IEO (Spain)	
Subareas	IXa N	IXa CN-IXa S		IXa CN-IXa S	IXa S		IXa S	IXa S	
Year/Quarter	Q2	Q1	Q2	Q4	Q2	Q3	Q4	Q2	Q3
1998				Nov					
1999		Mar (1,2)							
2000				Nov					
2001		Mar (1,2)		Nov					
2002		Mar (1,2)							
2003		Feb (1,2)		(Nov)					
2004			(Jun)		Jun(2)				
2005			Apr(1,2)	(Nov)				Jun(2)	
2006			Apr(1,2)	(Nov)	Jun(2)				
2007			Apr(1,2)	Nov		Jul (2)			
2008	Apr (2)		Apr(1,2)	(Nov)				Jun(2)	
2009	Apr (2)		Apr (2)		Jun(2)	(Jul)(3)	(Oct)		
2010	Apr (2)		Apr (2)			(Jul)(2)			
2011	Apr (2)		Apr (2)						Jul(2)
2012	Apr (2)						Nov		
2013	Mar (2)		Apr (2)						

Table 4.3.2.2. Anchovy in Division IXa. *PELACUS* survey series (spring Spanish acoustic survey in Sub-division IXa North and Sub-area VIII c). Historical series of acoustic estimates of anchovy abundance (N, millions) and biomass (B, tonnes) in Sub-division IXa North.

Survey	Estimate	IXa North
Apr. 08	N	10
	B	306
Apr. 09	N	0.7
	B	26
Apr. 10	N	0.03
	B	90
Apr. 11	N	73
	B	1650
Apr. 12	N	1
	B	45
Mar 13	N	-
	B	-

Table 4.3.2.3. Anchovy in Division IXa. *PELAGO* survey series (spring Portuguese acoustic survey in Sub-divisions IXa Central-North to IXa South). Historical series of overall and regional acoustic estimates of anchovy abundance (N, millions) and biomass (B, tonnes).

Survey	Estimate	Portugal				Spain	S(Total)	TOTAL
		C-N	C-S	S(A)	Total	S(C)		
Mar. 99	N	22	15	*	37	2079	2079	2116
	B	190	406	*	596	24763	24763	25359
Mar. 00	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Mar. 01	N	25	13	285	324	2415	2700	2738
	B	281	87	2561	2929	22352	24913	25281
Mar. 02	N	22	156	92	270	3731 **	3823 **	4001 **
	B	472	1070	1706	3248	19629 **	21335 **	22877 **
Feb. 03	N	0	14	*	14	2314	2314	2328
	B	0	112	*	112	24565	24565	24677
Mar. 04	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Apr. 05	N	-	59	-	59	1306	1306	1364
	B	-	1062	-	1062	14041	14041	15103
Apr. 06	N	-	-	319	319	1928	2246	2246
	B	-	-	4490	4490	19592	24082	24082
Apr. 07	N	0	103	284	387	2860	3144	3247
	B	0	1945	4607	6552	33413	38020	39965
Apr.08	N	69	252	213	534	1819	2032	2353
	B	3000	2505	4661	10166	29501	34162	39667
Apr.09	N	127	0****	159	286	1910	2069	2196
	B	2089	0****	3759	5848	20986	24745	26834
Apr. 10	N	0	62	0	62	963	963	1026
	B	0	1188	0	1188	7395	7395	8583
Apr. 11	N	1558	0	0	1558	0	0	1558
	B	27050	0	0	27050	0	0	27050
Apr. 12	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Apr. 13	N	251	0	263	514	634	897	1148
	B	3955	0	5044	8999	7656	12700	16655

* Due to the distribution observed during the survey, the last transect (near the border with Spain) that normally belongs to the Algarve sub-area was included in Cadiz.** Corrected estimates after detection of errors in the sA values attributed to the Cadiz area (Marques & Morais, 2003). ****Possible underestimation: although no echo-traces attributable to the species were detected in this area, however, the loss of pelagic gear samplers prevented from confirming directly this.

Table 4.3.2.4. Anchovy in Division IXa. ***ECOCÁDIZ*** **survey series (summer Spanish acoustic survey in Sub-division IXa South). Historical series of overall and regional acoustic estimates of anchovy abundance (N, millions) and biomass (B, tonnes).**

Survey	Estimate	Portugal	Spain	TOTAL
		S(A)	S(C)	S(Total)
Jun. 04***	N	125	1109	1235
	B	2474	15703	18177
Jun. 05	N	-	-	-
	B	-	-	-
Jun. 06	N	363	2801	3163
	B	6477	30043	36521
Jul. 07	N	558	1232	1790
	B	11639	17243	28882
Jul. 08	N	-	-	-
	B	-	-	-
Jul. 09	N	35	1102	1137
	B	1075	20506	21580
Jul. 10	N	?	954+	954 +
	B	?	12339 +	12339 +
Jul. 11	N	-	-	-
	B	-	-	-
Jul. 12	N	-	-	-
	B	-	-	-

***Possible underestimation: shallow waters between 20 and 30 m depth were not acoustically sampled+ Partial estimate due to an incomplete coverage of the sub-division (only the Spanish part).

Table 4.3.2.5. Anchovy in Division IXa. *SAR* autumn survey series (autumn Portuguese acoustic survey in Sub-divisions IXa Central-North to IXa South). Historical series of overall and regional acoustic estimates of anchovy abundance (N, millions) and biomass (B, tonnes).

Survey	Estimate	Portugal				Spain	S(Total)	TOTAL
		C-N	C-S	S(A)	Total	S(C)		
Nov. 98	N	30	122	50	203	2346	2396	2549
	B	313	1951	603	2867	30092	30695	32959
Nov. 99	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Nov. 00	N	4	20	*	23	4970	4970	4994
	B	98	241	*	339	33909	33909	34248
Nov. 01	N	35	94	-	129	3322	3322	3451
	B	1028	2276	-	3304	25578	25578	28882
Nov. 02	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Nov. 03	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Nov. 04	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Nov. 05	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Nov. 06	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Nov. 07	N	0	59	475	534	1386	1862	1921
	B	0	1120	7632	8752	16091	23723	24843

* Due to the distribution observed during the survey, the last transect (near the border with Spain) that normally belongs to the Algarve sub-area was included in Cadiz

Table 4.3.2.6. Anchovy in Division IXa. *ECOCÁDIZ-RECLUTAS* survey series (autumn Spanish acoustic survey in Sub-division IXa South). Historical series of overall and regional acoustic estimates of anchovy abundance (N, millions) and biomass (B, tonnes).

Survey	Estimate	Portugal	Spain	TOTAL
		S(A)	S(C)	S(Total)
Nov. 12*	N	-	2649	
	B	-	13680	

* Partial estimate because only the Spanish waters were acoustically surveyed.

Table 4.4.1.1. Anchovy in Division IXa. Sub-division IXa South. Mean weight at age in the stock (in g).

Year	Age 0	Age 1	Age 2	Age 3
1995	7.030	10.720	22.550	
1996	1.056	6.256	19.983	
1997	2.574	11.061	20.900	
1998	2.646	7.404	20.449	
1999	3.187	12.839	19.988	
2000	3.137	9.963	23.817	
2001	6.210	13.288	31.765	
2002	3.319	10.500	26.286	
2003	5.982	10.566	26.789	
2004	6.644	12.009	21.875	
2005	4.936	9.166	22.619	
2006	3.651	8.214	20.970	
2007	5.358	9.442	20.385	
2008	7.181	14.934	21.768	23.093
2009	4.120	12.194	20.261	24.207
2010	6.911	11.309	19.088	22.987
2011	8.230	10.323	22.731	
2012	8.300	14.326	22.530	

Table 4.4.2.1. Anchovy in Division IXa. Sub-division IXa South. Maturity ogives (ratio of mature fish at age) for Gulf of Cadiz anchovy.

Year	Age		
	0	1	2+
1988	0	0.82	1
1989	0	0.53	1
1990	0	0.65	1
1991	0	0.76	1
1992	0	0.53	1
1993	0	0.77	1
1994	0	0.60	1
1995	0	0.76	1
1996	0	0.49	1
1997	0	0.63	1
1998	0	0.55	1
1999	0	0.74	1
2000	0	0.70	1
2001	0	0.76	1
2002	0	0.72	1
2003	0	0.69	1
2004	0	0.95	1
2005	0	0.95	1
2006	0	0.77	1
2007	0	0.91	1
2008	0	0.97	1
2009	0	0.99	1
2010	0	0.97	1
2011	0	0.97	1
2012	0	0.89	1

Table 4.4.2.1. Anchovy in Division IXa. Sub-division IXa South. Length-based exploratory assessment for Gulf of Cadiz anchovy. Analysis based in Length–frequency data of landings summed for the period 2004–2012.

Variable	Estimate	Source
L_c	9.25	WGHANSA data (2004-2012 pooled LFD of total annual landings)
Linf	18.69	Bellido *et al.* (2000)
Lmat	9.28	IEO's DCF data base (arithmetic mean of annual 2004-2012 estimates)
L(F=M)	11.61	WGHANSA data (2004-2012 pooled LFD of total annual landings)
Lopt	12.46	WGHANSA data (2004-2012 pooled LFD of total annual landings)
Lmean	12.08	WGHANSA data (2004-2012 pooled LFD of total annual landings)
	Exploratory analysis	
SSB relative to SSB MSY	Lc ≈ Lmat (SSB might be at a relatively low risk of being below SSBMSY or MSY Btrigger)	
F relative to FMSY	Lmean >>>> Lmat (OK)	
F relative to FMSY	Lmean >≈ L(F=M) (F is likely to be somewhat lower than M therefore, likely sustainable)	
F	Lmean ≈ Lopt (Stock exploited close Sustainable fishery close to MSY)	

Table 4.5.2.1. Anchovy in Division IXa. Sub-division IXa South. Assessment of yearly harvest rates on anchovy in the Gulf of Cadiz (IXa South) with the assumption of catchability equal 1 for all surveys (and averaging annual estimates).

EXPLOITATION STATUS QUO OF ANCHOVY IN IXA South

Biomass (tonnes)	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	TOTAL
PELAGO (Acoustic)	24.763		24.913	21.335	24.565		14.041	24.082	38.020	34.162	24.745	7.395	0	
ECOCADIZ (Acoustic)						18.177		36.521	28.882		21.580	12.339		
BOCADEVA (DEPM)							14.637			31.527			32.757	
Mean Biomas (For q=1)	24.763		24.913	21.335	24.565	18.177	14.339	30.301	33.451	32.845	23.163	9.867	32.757	290.476
Catches	5.942	2.360	8.655	8.262	4.968	5.617	4.423	4.381	5.610	3.204	2.954	2.929	6.294	63.240
Harvest Rate	24%		35%	39%	20%	31%	31%	14%	17%	10%	13%	30%	19%	22%

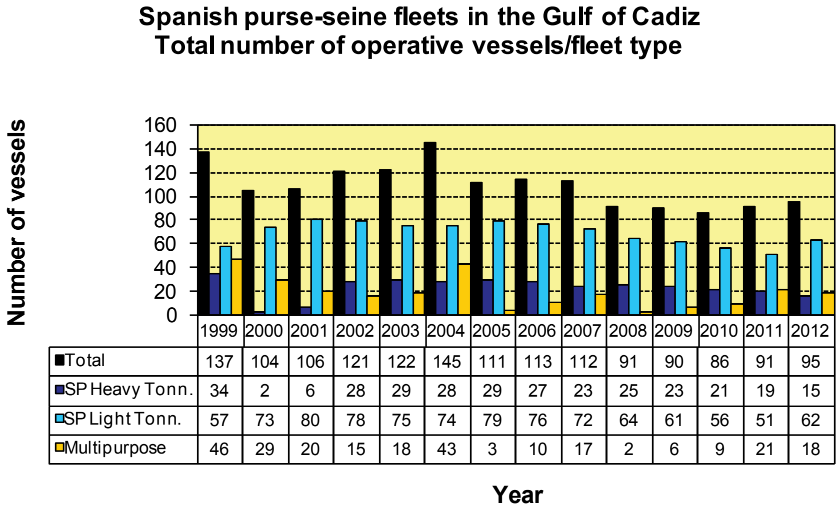
Q														Mean	Desvest	CV	MAX	min
0.6	0.14398		0.20844	0.23236	0.12134	0.18542	0.18506	0.08676	0.10062	0.05854	0.07652	0.1781	0.11529	0.14104	0.0562	0.3986	23.2%	5.9%
0.8	0.19197		0.27792	0.30981	0.16178	0.24723	0.24675	0.11568	0.13416	0.07805	0.10203	0.23747	0.15372	0.18805	0.0750	0.3986	31.0%	7.8%
1	0.23996		0.3474	0.38726	0.20223	0.30904	0.30844	0.1446	0.1677	0.09756	0.12754	0.29683	0.19216	0.23506	0.0937	0.3986	38.7%	9.8%
1.2	0.28795		0.41688	0.46471	0.24267	0.37084	0.37012	0.17351	0.20124	0.11708	0.15304	0.3562	0.23059	0.28207	0.1124	0.3986	46.5%	11.7%
1.4	0.33595		0.48636	0.54216	0.28312	0.43265	0.43181	0.20243	0.23478	0.13659	0.17855	0.41557	0.26902	0.32908	0.1312	0.3986	54.2%	13.7%

Table 4.5.2.2. Anchovy in Division IXa. Sub-division IXa South. Sensitivity of the Status Quo exploitation of Anchovy in IXa South to different levels of average catchability of surveys.

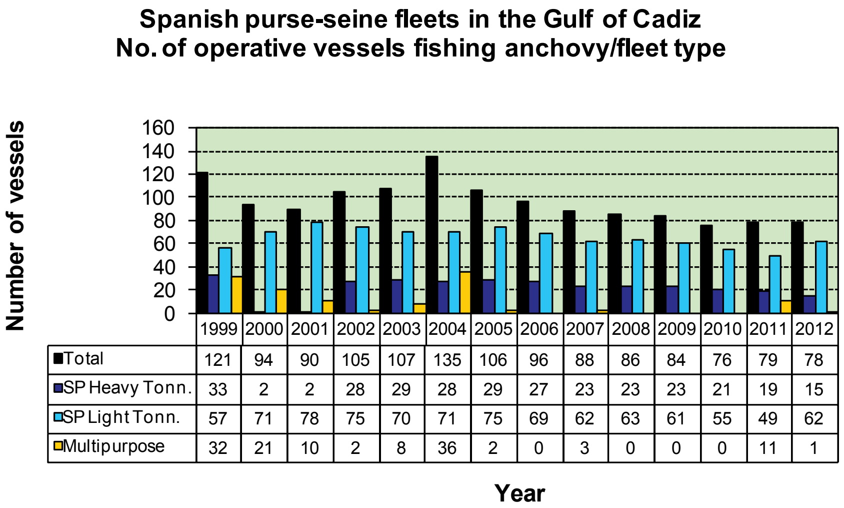
Sensitivity Assessment	0.6	0.8	1	1.2	1.4	1.6	1.8	2
Catchability of Surveys	q = 0.6	q = 0.8	q = 1	q = 1.20	q = 1.40			
Mean Harvest Rate (HR)	14.1%	18.8%	23.5%	28.2%	32.9%			
HR standard Deviation	5.62%	7.50%	9.37%	11.24%	13.12%			
CV	0.399	0.399	0.399	0.399	0.399			
MIN (HR)	5.9%	7.8%	9.8%	11.7%	13.7%			
MAX (HR)	23.2%	31.0%	38.7%	46.5%	54.2%	62.0%	69.7%	77.5%

Table 4.7.1. Anchovy in Division IXa. Sub-division IXa South. Fishing mortaltity (F) and Harvest Rate (HR) reference points for a) the average age composition of the catches (1999-2011) and b) years with high presence of age 0 (1996, 97, 98 and 2011). Note: F reference points in terms of Fbar(ages 1-3).

a) First set of % of catches at age (Average % of age 0 in catches = 17%)								**F Reference Points**					**HR reference points**			
ANALISIS	**Fitted selectivity**	S_0	S_1	S_2	S_3	S_4+		**F_SBR50%**	**F_SBR40%**	**F_SBR35%**	**F_0.1**		**HR_SBR50%**	**HR_SBR40%**	**HR_SBR35%**	**HR_0.1**
Fitted at F (age 1)	0.02	0.0627	1.0000	0.1218	0.0074	0.0000		**0.32**	**0.44**	**0.50**	**1.19**		**0.78**	**1.18**	**1.44**	**7.09**
Fitted at F (age 1)	0.20	0.0580	1.0000	0.1372	0.0084	0.0000		**0.33**	**0.44**	**0.51**	**1.20**		**0.77**	**1.17**	**1.44**	**6.94**
Fitted at F (age 1)	0.40	0.0535	1.0000	0.1575	0.0099	0.0000		**0.33**	**0.45**	**0.52**	**1.21**		**0.77**	**1.17**	**1.43**	**6.71**
Fitted at F (age 1)	0.60	0.0494	1.0000	0.1822	0.0118	0.0000		**0.34**	**0.46**	**0.53**	**1.23**		**0.78**	**1.17**	**1.44**	**6.51**
Fitted at F (age 1)	0.80	0.0459	1.0000	0.2124	0.0143	0.0000		**0.35**	**0.47**	**0.54**	**1.24**		**0.78**	**1.17**	**1.44**	**6.25**
Fitted at F (age 1)	1.00	0.0428	1.0000	0.2502	0.0179	0.0000		**0.36**	**0.48**	**0.56**	**1.26**		**0.78**	**1.16**	**1.46**	**6.02**
Fitted at F (age 1)	1.20	0.0400	1.0000	0.2984	0.0225	0.0000		**0.37**	**0.50**	**0.58**	**1.28**		**0.78**	**1.18**	**1.44**	**5.69**
Fitted at F (age 1)	1.40	0.0374	1.0000	0.3618	0.0303	0.0000		**0.39**	**0.52**	**0.60**	**1.30**		**0.79**	**1.18**	**1.45**	**5.36**
b) Second set of Catches at age (Average % of age 0 in catches = 43%)								**F Reference Points**					**HR reference points**			
ANALISIS	**for a selectivity**	S_0	S_1	S_2	S_3	S_4+		**F_SBR50%**	**F_SBR40%**	**F_SBR35%**	**F_0.1**		**HR_SBR50%**	**HR_SBR40%**	**HR_SBR35%**	**HR_0.1**
Fitted at F (age 1)	0.20	0.2121	1.0000	0.1522	0.0000	0.0000		**0.27**	**0.37**	**0.42**	**1.10**		**0.79**	**1.21**	**1.49**	**9.97**
Fitted at F (age 1)	0.60	0.1760	1.0000	0.2029	0.0000	0.0000		**0.29**	**0.39**	**0.46**	**1.14**		**0.79**	**1.19**	**1.50**	**8.67**
Fitted at F (age 1)	1.00	0.1493	1.0000	0.2805	0.0000	0.0000		**0.32**	**0.43**	**0.49**	**1.19**		**0.79**	**1.21**	**1.48**	**7.65**
Fitted at F (age 1)	1.40	0.1291	1.0000	0.4112	0.0000	0.0000		**0.34**	**0.46**	**0.54**	**1.24**		**0.79**	**1.18**	**1.49**	**6.54**



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Total	137	104	106	121	122	145	111	113	112	91	90	86	91	95
SP Heavy Tonn.	34	2	6	28	29	28	29	27	23	25	23	21	19	15
SP Light Tonn.	57	73	80	78	75	74	79	76	72	64	61	56	51	62
Multipurpose	46	29	20	15	18	43	3	10	17	2	6	9	21	18



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Total	121	94	90	105	107	135	106	96	88	86	84	76	79	78
SP Heavy Tonn.	33	2	2	28	29	28	29	27	23	23	23	21	19	15
SP Light Tonn.	57	71	78	75	70	71	75	69	62	63	61	55	49	62
Multipurpose	32	21	10	2	8	36	2	0	3	0	0	0	11	1

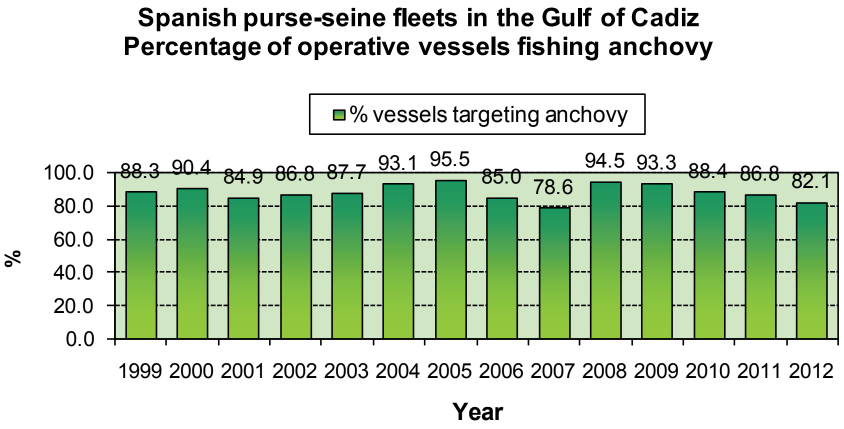


Figure 4.2.1.1. Anchovy in División IXa. Sub-division IXa South. Spanish purse-seine fishery. Fleet composition operating in the Gulf of Cadiz fishery since 1999. The fleet is differentiated into total fleet and vessels targeting anchovy. The categories include both single purpose purse-seiners and trawl and artisanal vessels fishing with purse-seine in some periods through the year (multi-purpose vessels).

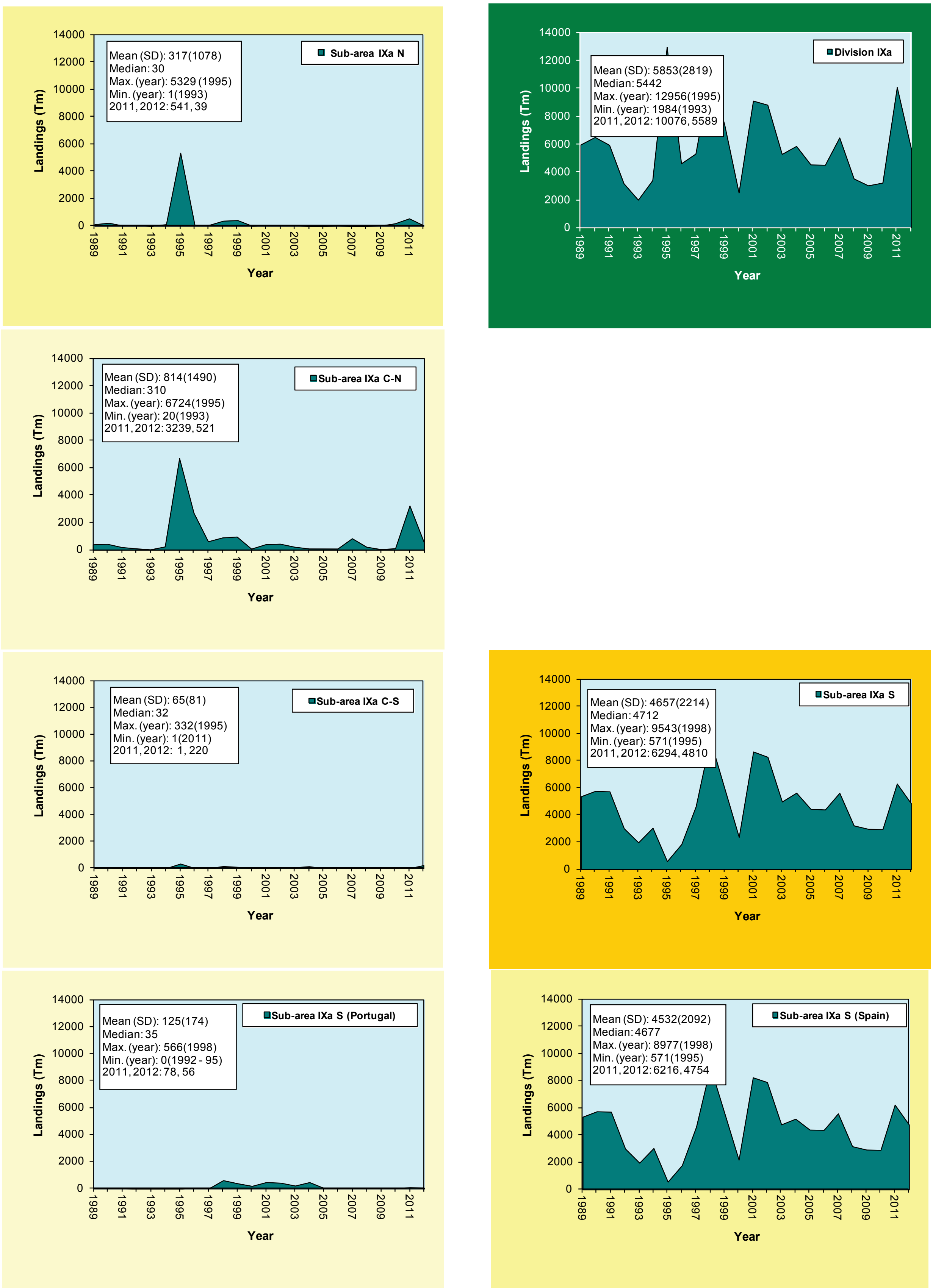


Figure 4.2.2.1.1. Anchovy in Division IXa. Recent series of Portuguese and Spanish anchovy landings in Division IXa (1989-2011, the period with data for all the Sub-divisions). Sub-areas arranged according to its geographical location along the Atlantic Iberian Peninsula. Series for the whole Division and for the whole Sub-area IXa-South are also shown.

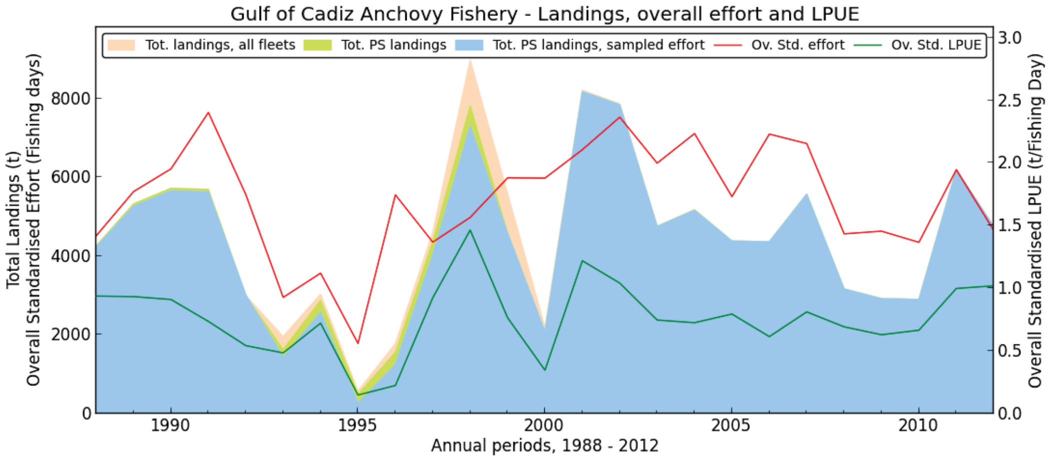


Figure 4.2.4.1. Anchovy in Division IXa. Sub-division IXa South. Spanish purse-seine fishery. Trends in Gulf of Cadiz anchovy annual landings, and purse-seine fleets' standardised overall effort and LPUE (1988-2012).

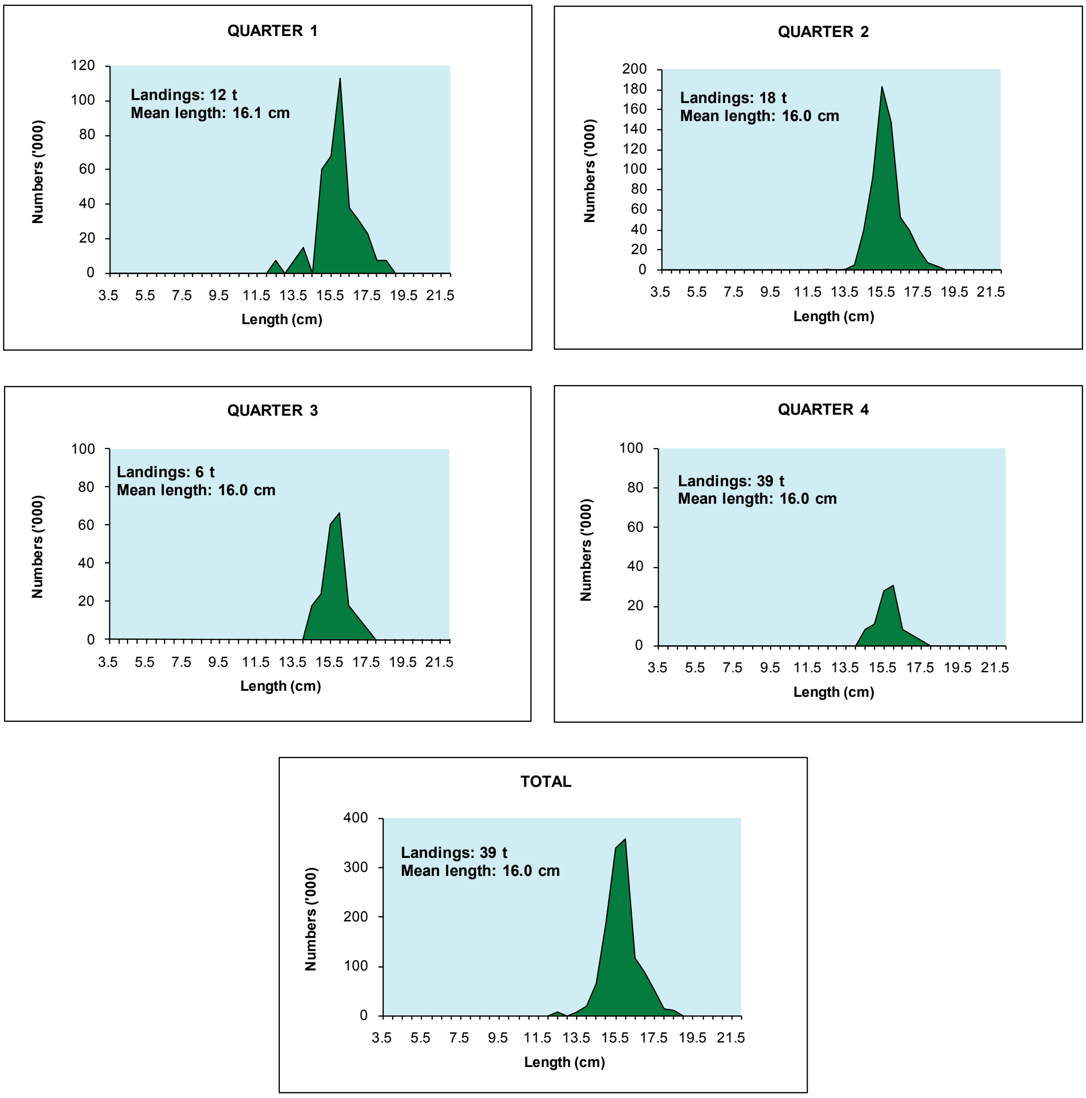


Figure 4.2.5.1.1. Anchovy in Division IXa. Sub-division IXa North. Spanish fishery (all fleets). Quarterly and annual length distributions ('000) of Spanish landings of Western Galicia anchovy in 2012.

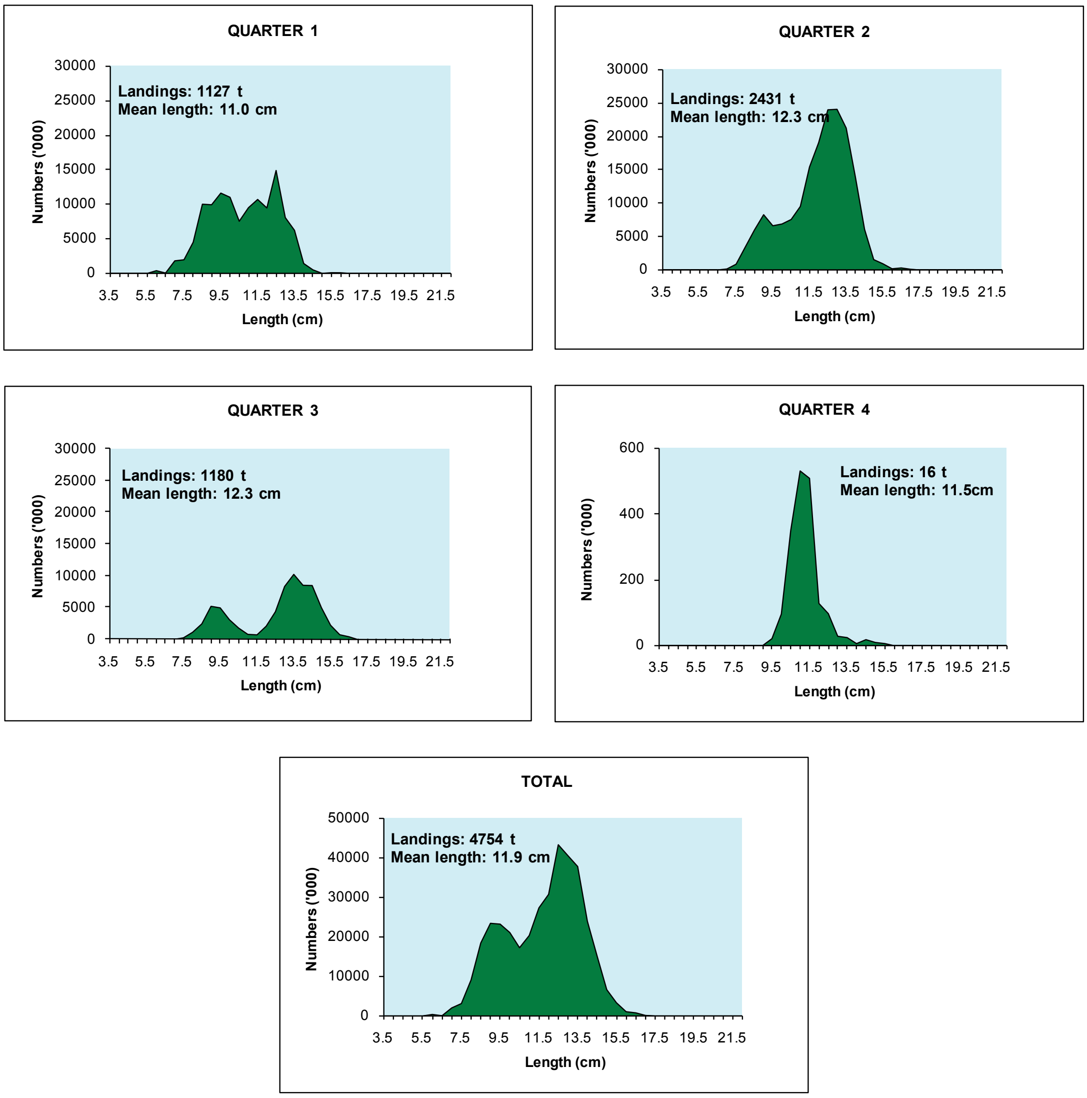


Figure 4.2.5.1.2. Anchovy in Division IXa. Sub-division IXa South. Spanish fishery (all fleets). Quarterly and annual length distributions ('000) of Spanish landings of Gulf of Cadiz anchovy in 2012.

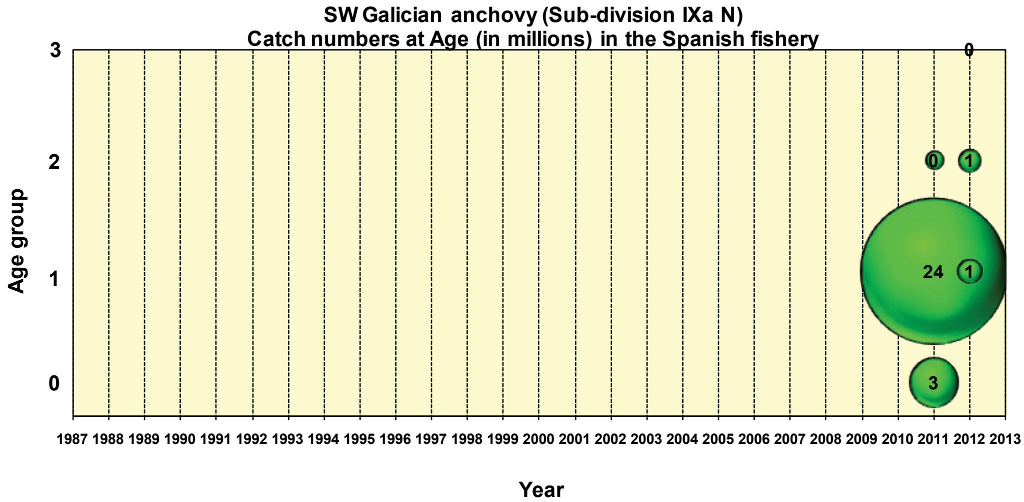


Figure 4.2.5.2.1. Anchovy in Division IXa. Sub-division IXa North. Spanish fishery (all fleets). Age composition in Spanish landings of SW Galician anchovy (only 2011 and 2012 data available).

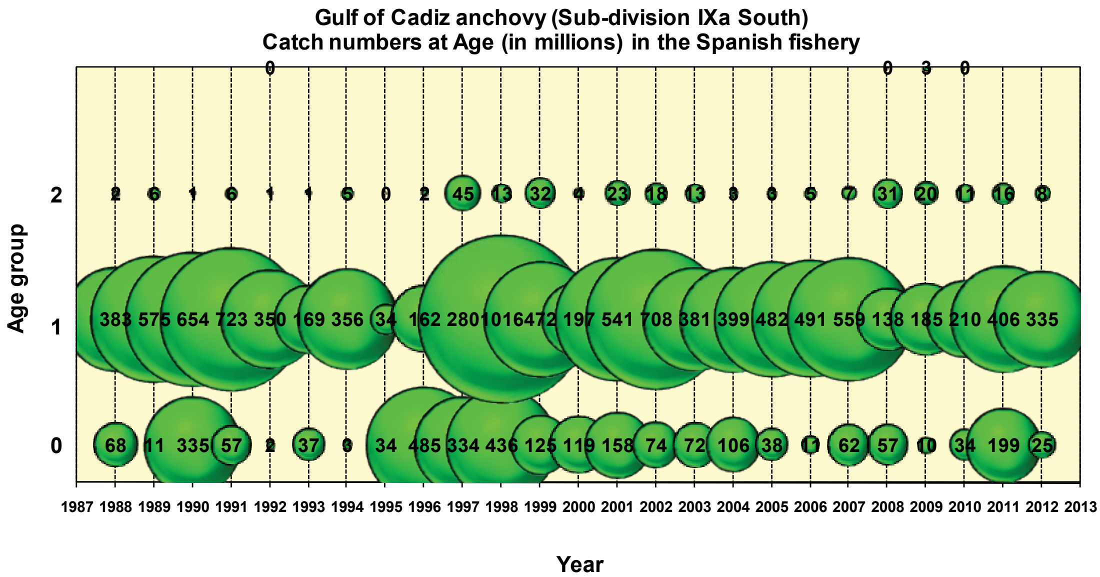
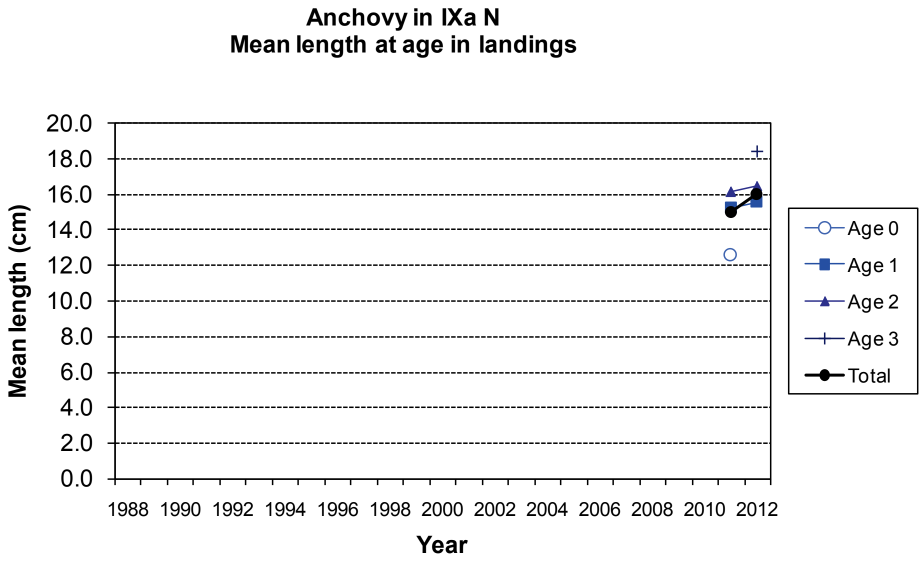


Figure 4.2.5.2.2. Anchovy in Division IXa. Sub-division IXa-South. Spanish fishery (all fleets). Age composition in Spanish landings of Gulf of Cadiz anchovy (1988-2012). Data for 1994 and second half in 1995 estimated from an iterated ALK by applying the Kimura and Chikuni's (1987) algorithm.



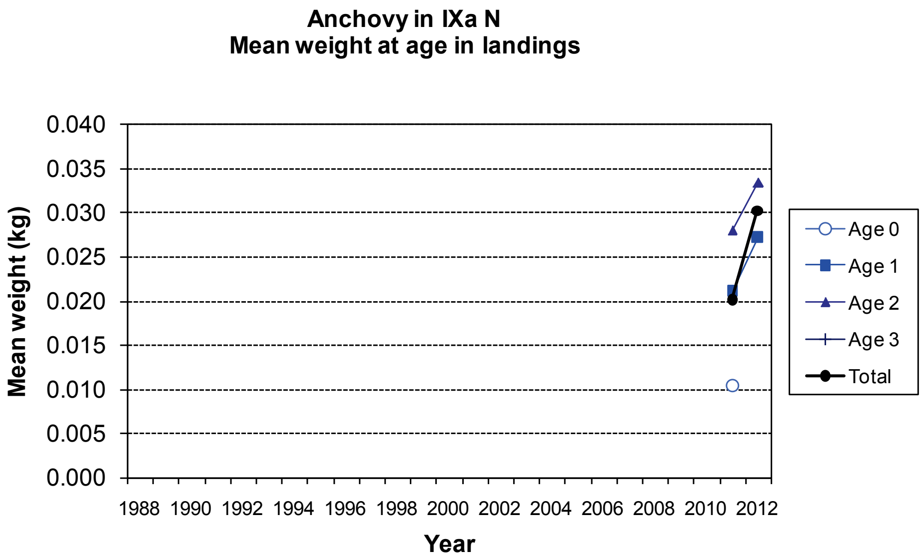
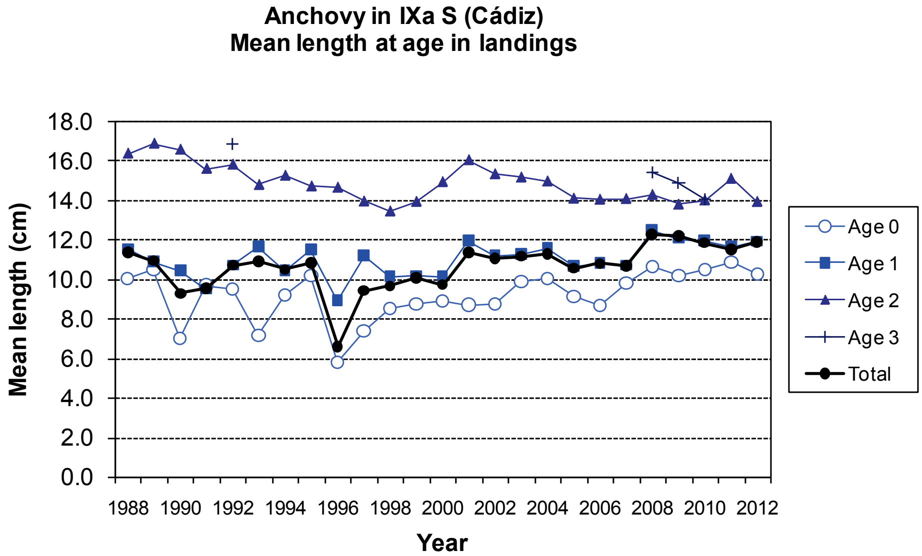


Figure 4.2.6.1. Anchovy in Division IXa. Sub-division IXa North. Spanish fishery (all fleets). Annual mean length (TL, in cm) and weight (kg) at age in the Spanish landings of Western Galicia anchovy in 2012.



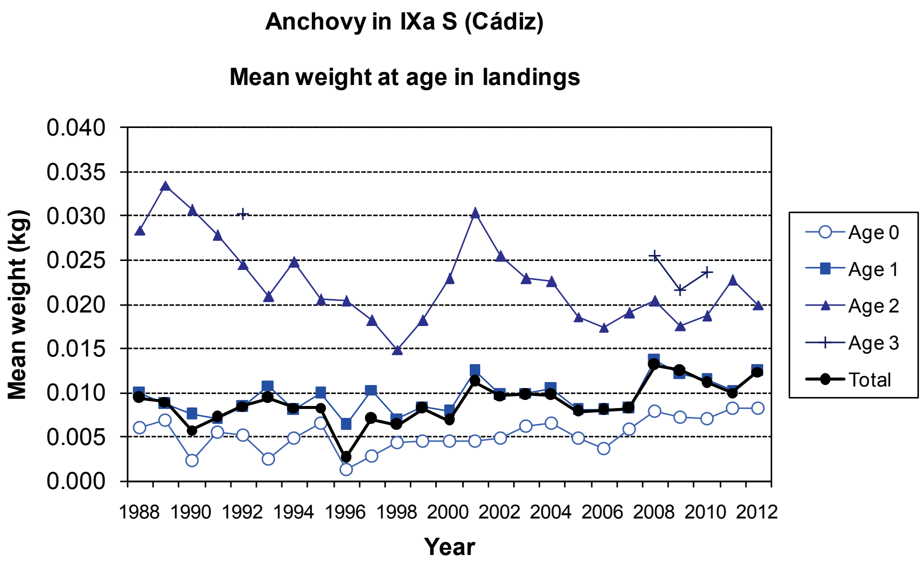


Figure 4.2.6.2. Anchovy in Division IXa. Sub-division IXa-South. Spanish fishery (all fleets). Annual mean length (TL, in cm) and weight (kg) at age in the Spanish landings of Gulf of Cadiz anchovy (1988-2012). Data for 1994 and second half in 1995 estimated from an iterated ALK by applying the Kimura and Chikuni's (1987) algorithm.

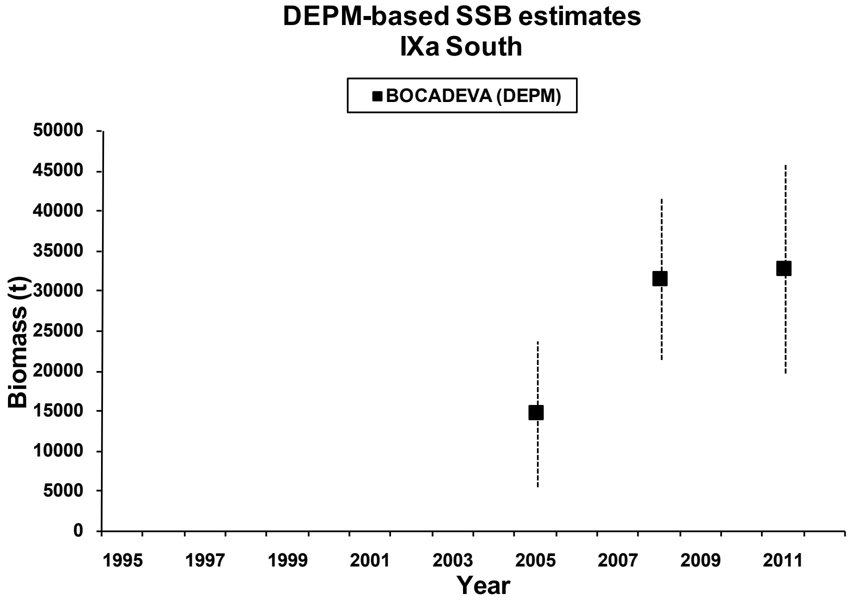


Figure 4.3.1.1. Anchovy in Division IXa. Sub-division IXa South. *BOCADEVA* survey series (summer Spanish DEPM survey in Sub-division IXa South). Series of SSB estimates (±SD) obtained from the survey series.

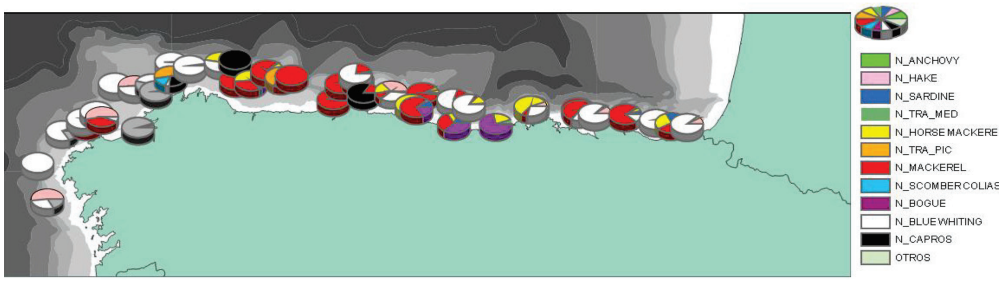


Figure 4.3.2.1. Anchovy in Division IXa. Sub-division IXa North. *PELACUS 0313* survey (spring Spanish acoustic survey in Sub-division IXa North and Sub-area VIII c in 2013). Distribution of pelagic hauls for echo-traces identification with indication of the species composition. Sub-division IXa North corresponds to the south westernmost geographical stratum.

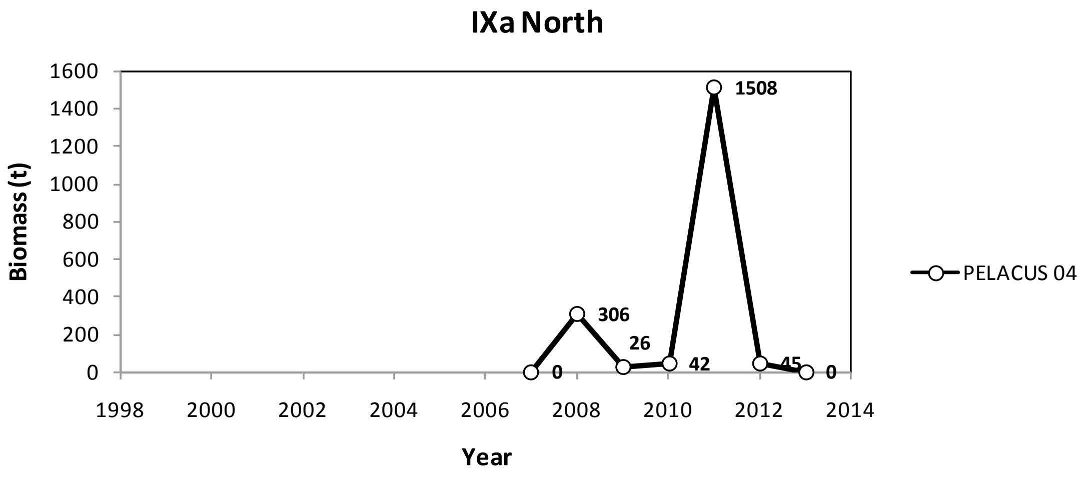


Figure 4.3.2.2. Anchovy in Division IXa. Sub-division IXa North. *PELACUS* survey series (spring Spanish acoustic survey in Sub-division IXa North and Sub-area VIII c). Historical series of acoustic estimates of anchovy biomass (t) for the Sub-division IXa North.

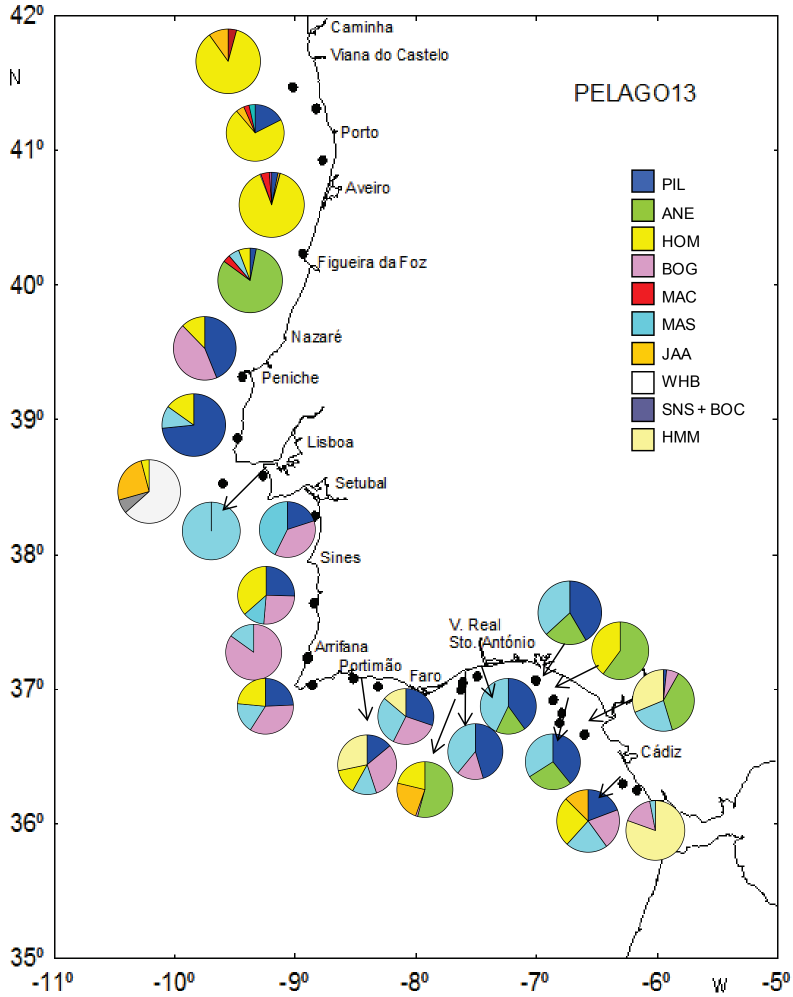


Figure 4.3.2.3. Anchovy in Division IXa. Sub-divisions IXa Central-North to IXa South. *PELAGO* survey series (spring Portuguese acoustic survey in Sub-divisions IXa Central-North to IXa South). *PELAGO 13* survey. Fishing trawls location and hauls species composition (in number).

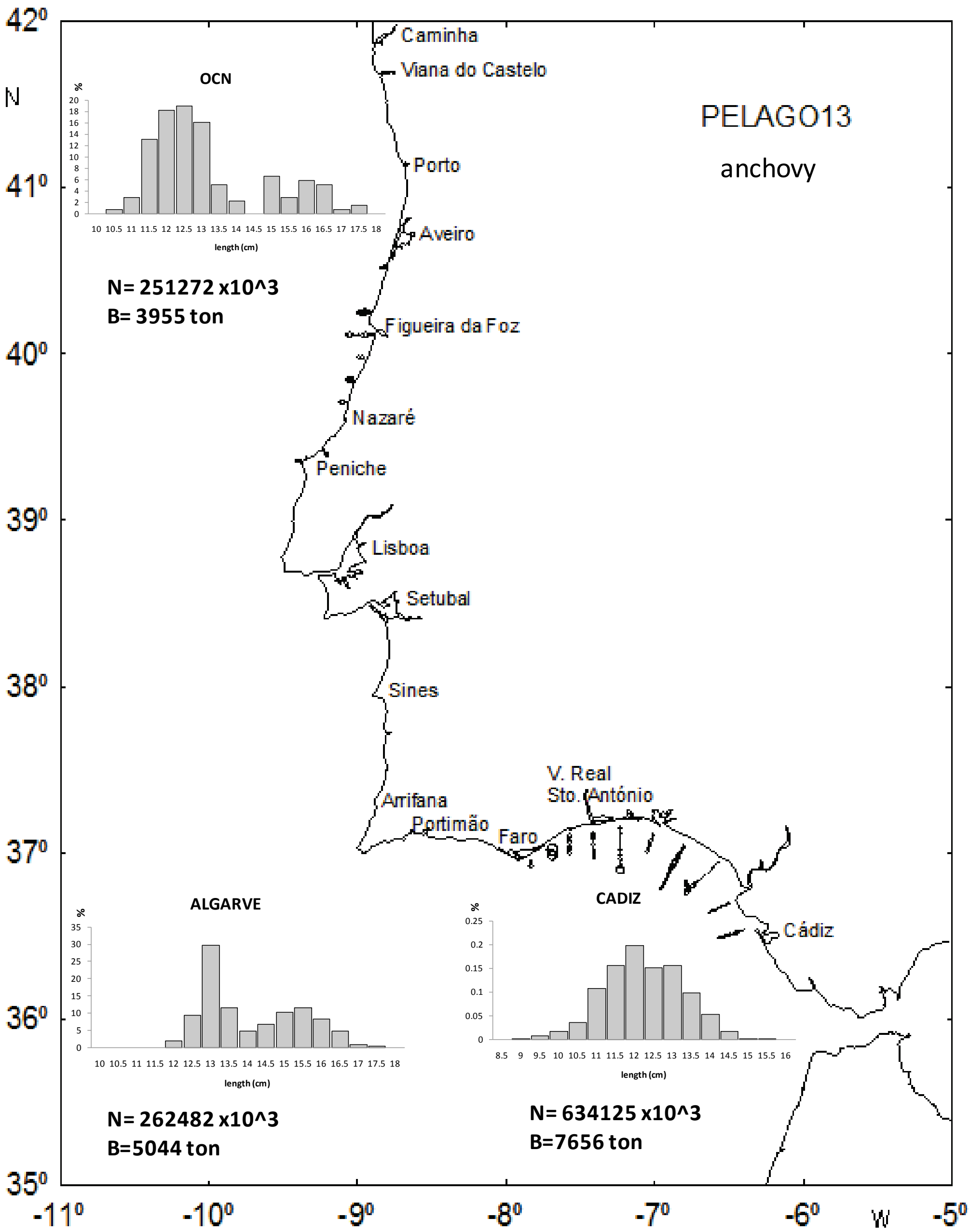
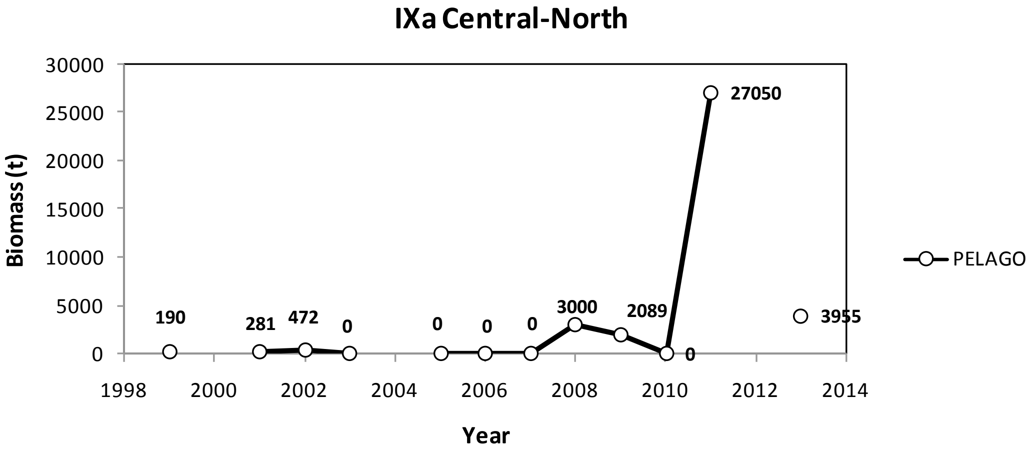
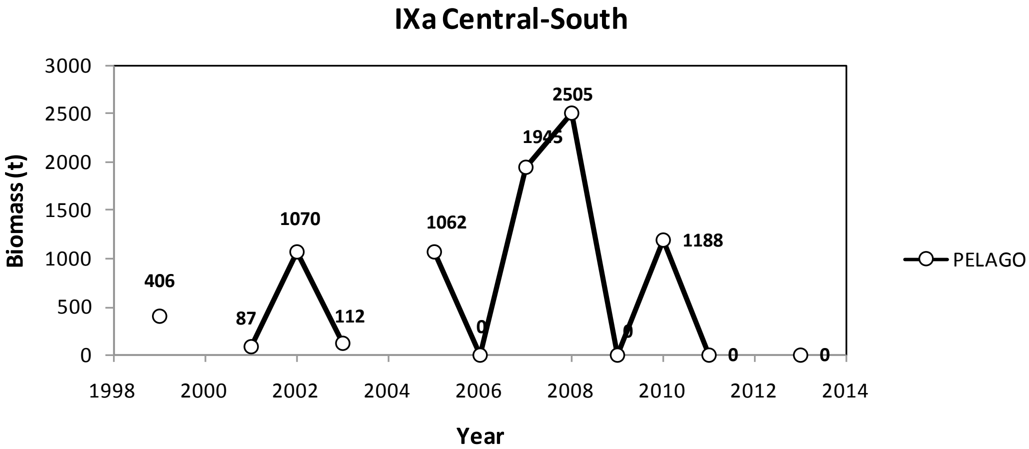


Figure 4.3.2.4. Anchovy in Division IXa. Sub-divisions IXa Central-North to IXa South. *PELAGO* survey series (spring Portuguese acoustic survey in Sub-divisions IXa Central-North to IXa South). *PELAGO 13* survey. Distribution of the NASC coefficients (m^2/mn^2) attributed to anchovy, acoustic estimates and size composition of the estimated populations by subareas.





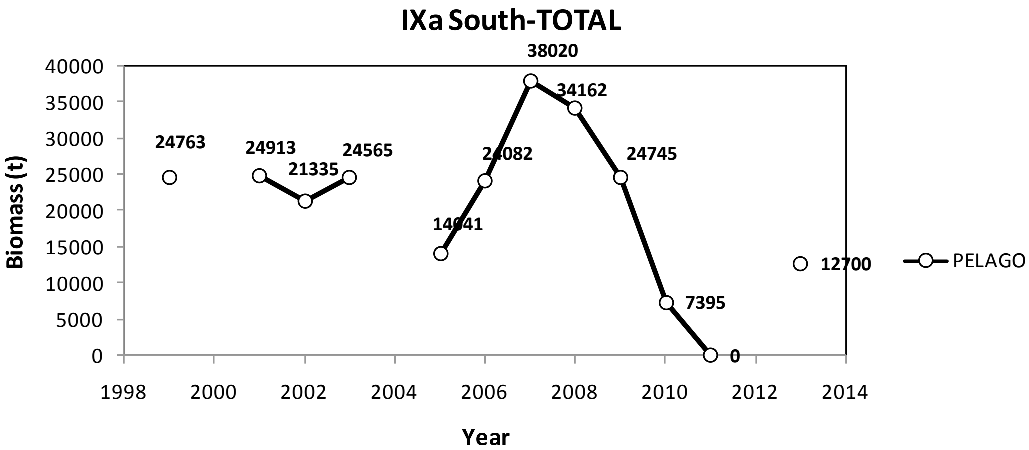
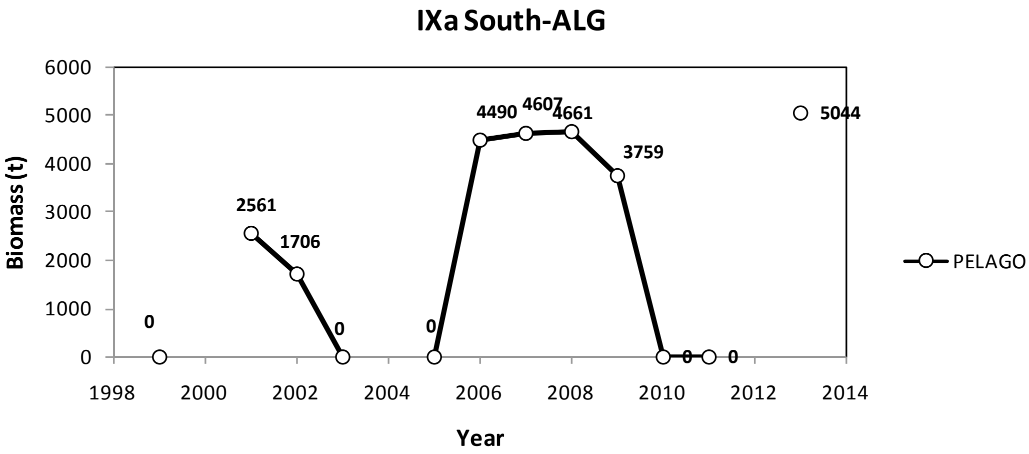


Figure 4.3.2.5. Anchovy in Division IXa. Sub-divisions IXa Central-North to IXa South. *PELAGO* survey series (spring Portuguese acoustic survey in Sub-divisions IXa Central-North to IXa South). Historical series of overall and regional acoustic estimates of anchovy biomass (t). Note the different scale of the y-axis.



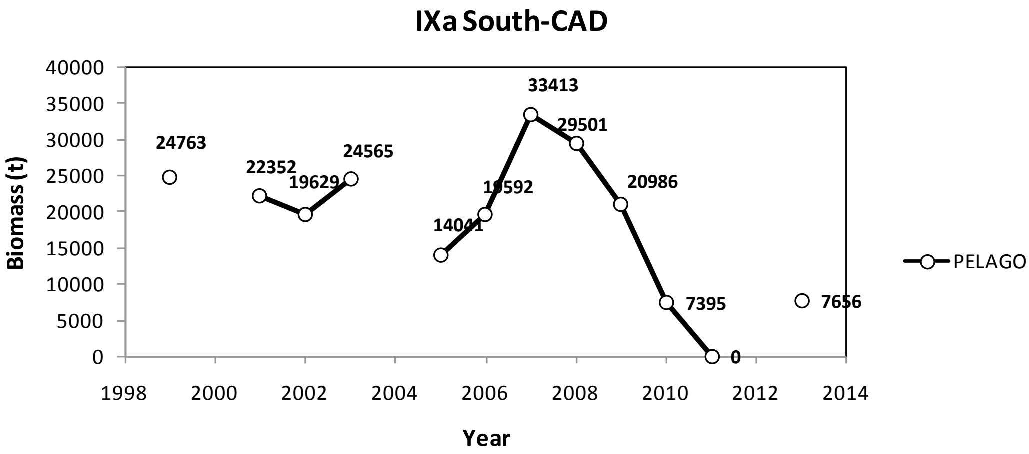
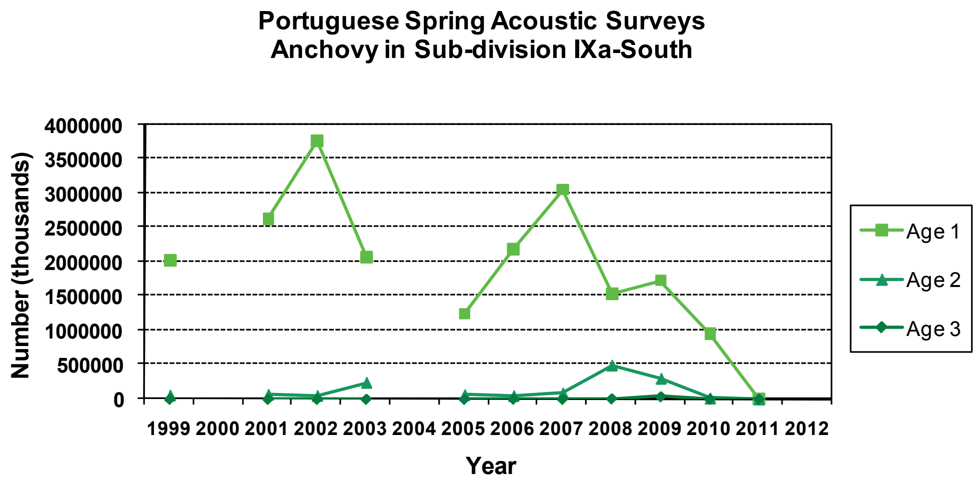


Figure 4.3.2.5 (cont'd). Acoustic estimates in the IXa South differentiated by Algarve (ALG) and Spanish waters of the Gulf of Cádiz (CAD). Note the different scale of the y-axis. Although estimates from Subdivision IXa-South in 2010 were not separately provided for Algarve and Cadiz to this WG, the total estimated for the Sub-division was assigned (by assuming some overestimation) to the Cadiz area according to the observed acoustic energy distribution in the area.



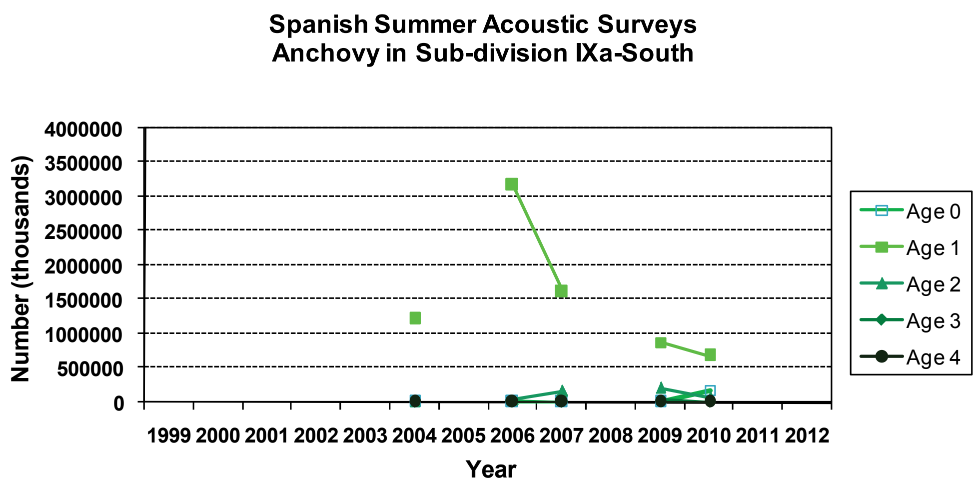


Figure 4.3.2.6. Anchovy in Division IXa. Sub-division IXa-South. Annual trends of the estimated population by age class from the Algarve + Gulf of Cádiz areas by the Portuguese Spring (PELAGO, upper plot) and Spanish summer (ECOCADIZ, lower plot) acoustic surveys. See text for explanations on the exclusion of 2013 age-structured estimates from the *PELAGO 13* survey.

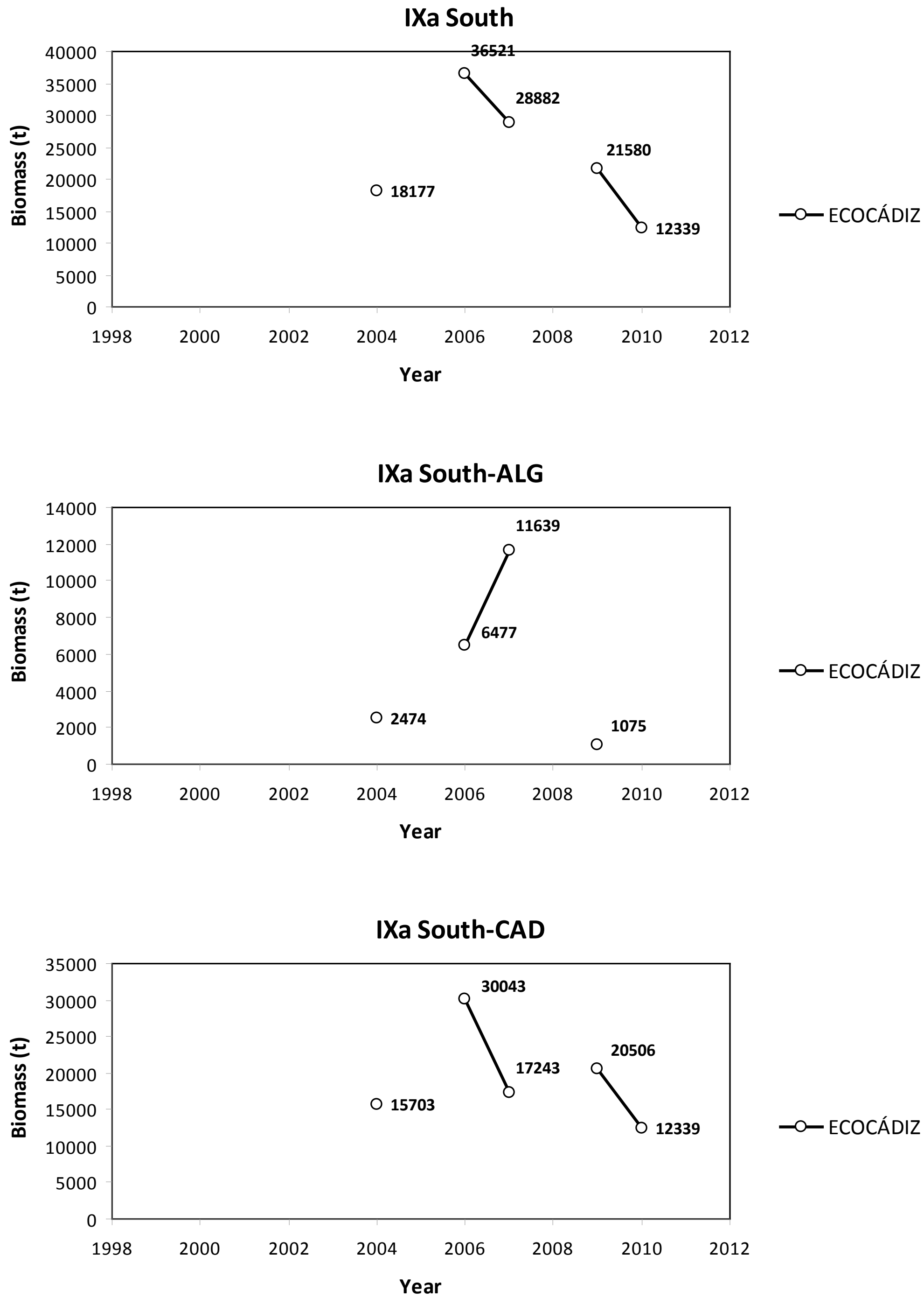


Figure 4.3.2.7. Anchovy in Division IXa. Sub-division IXa South. *ECOCÁDIZ* survey series (summer Spanish acoustic survey in Sub-division IXa South). Historical series of overall and regional (Algarve, ALG, and Spanish waters of the Gulf of Cádiz, CAD) acoustic estimates of anchovy biomass (t). Note the different scale of the y-axis.

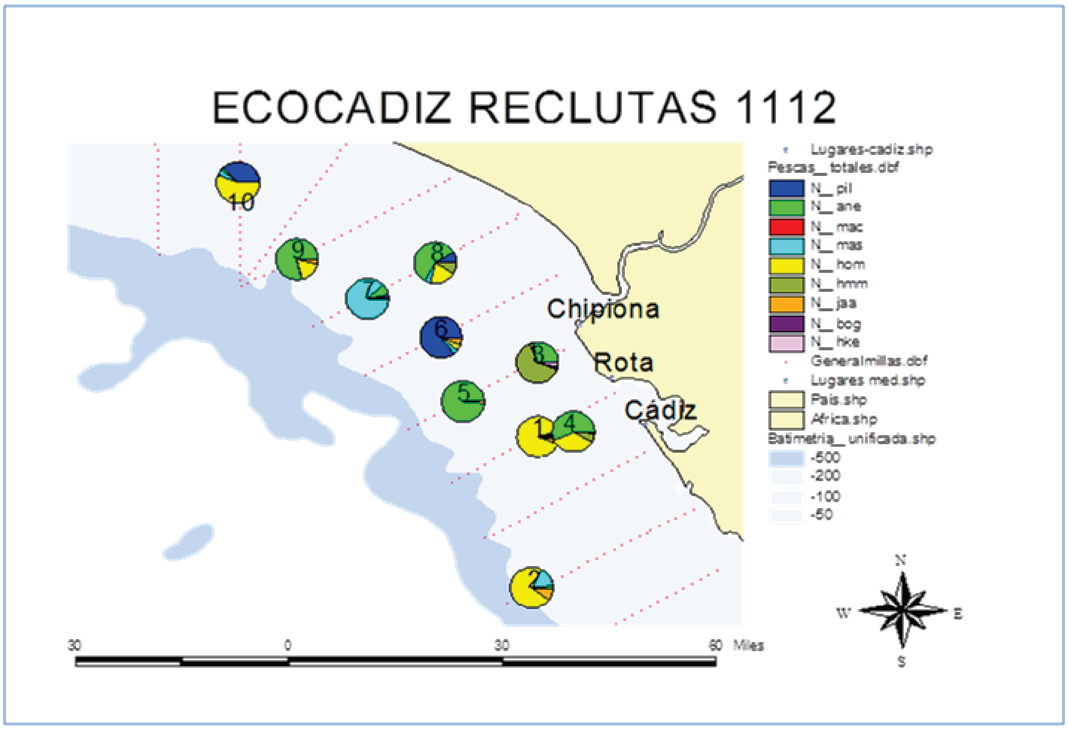


Figure 4.3.2.8. Anchovy in Division IXa. Sub-division IXa South. *ECOCÁDIZ-RECLUTAS 1112* survey (autumn Spanish acoustic survey in Sub-division IXa South). Location of valid fishing stations with indication of their species composition (percentages in number).

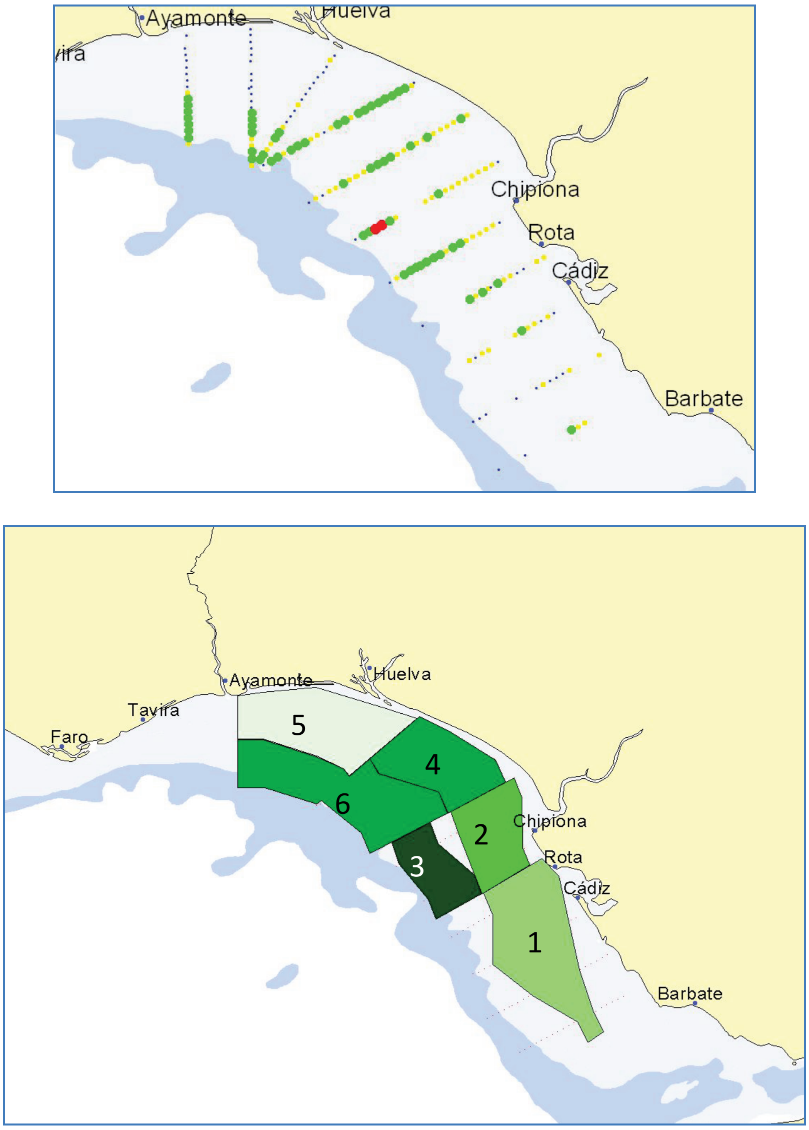


Figure 4.3.2.9. Anchovy in Division IXa. Sub-division IXa South. *ECOCÁDIZ-RECLUTAS 1112* survey (autumn Spanish acoustic survey in Sub-division IXa South). Top: Distribution of the backscattering energy (Nautical area scattering coefficient, NASC, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

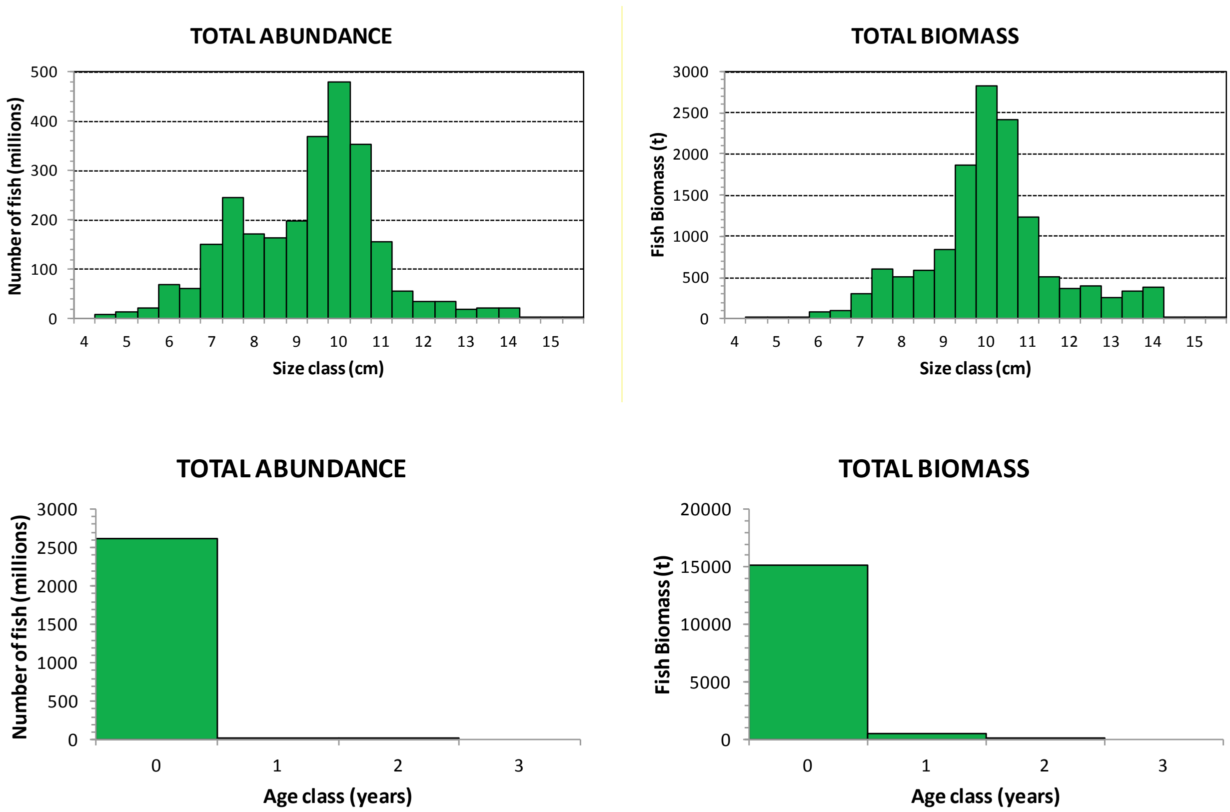


Figure 4.3.2.10. Anchovy in Division IXa. Sub-division IXa South. ***ECOCÁDIZ-RECLUTAS 1112*** **survey (autumn Spanish acoustic survey in Sub-division IXa South). Estimated abundances and biomasses (number of fish in millions and tonnes, respectively) for the surveyed area. Top row: by length class (cm). Bottom: by age group.**

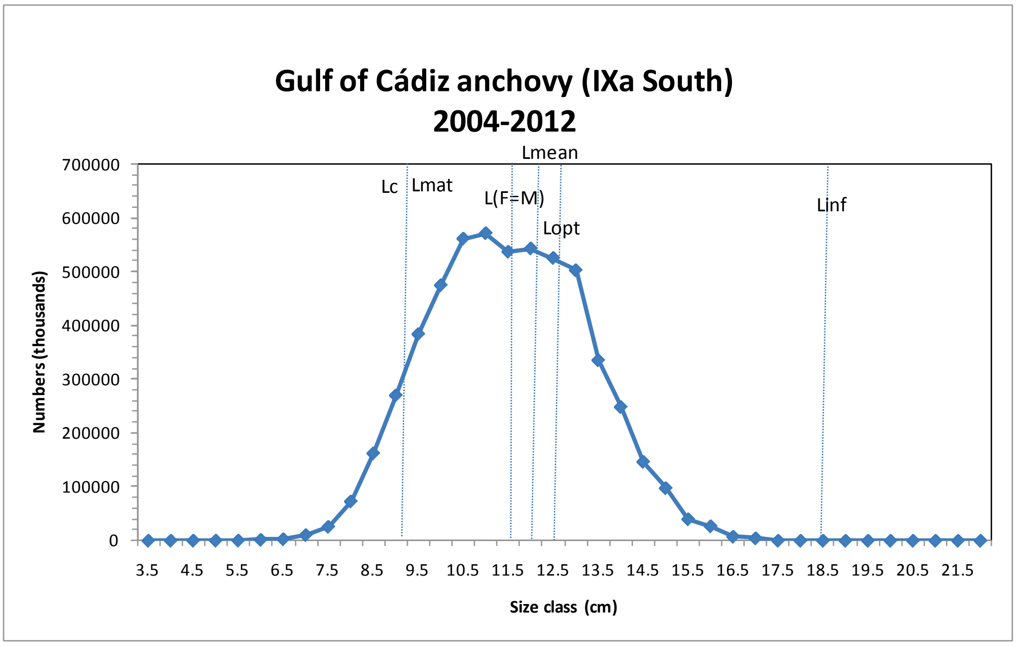
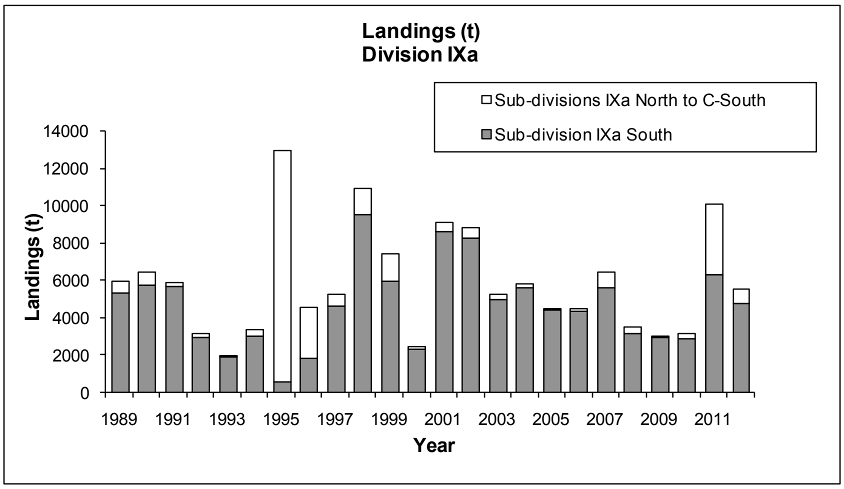
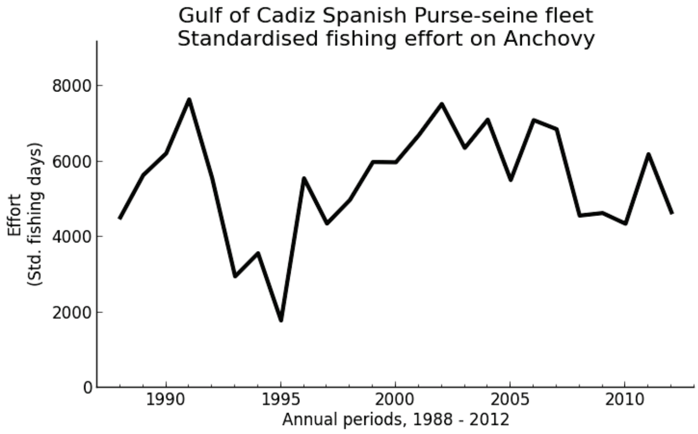


Figure 4.5.1.1. Anchovy in Division IXa. Anchovy in Sub-division IXa-South. Length-based exploratory assessment for Gulf of Cadiz anchovy. Analysis based in length–frequency data of landings summed for the period 2004–2012.





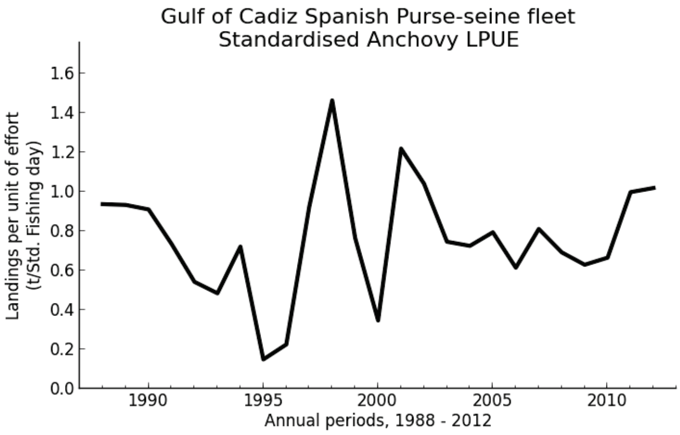
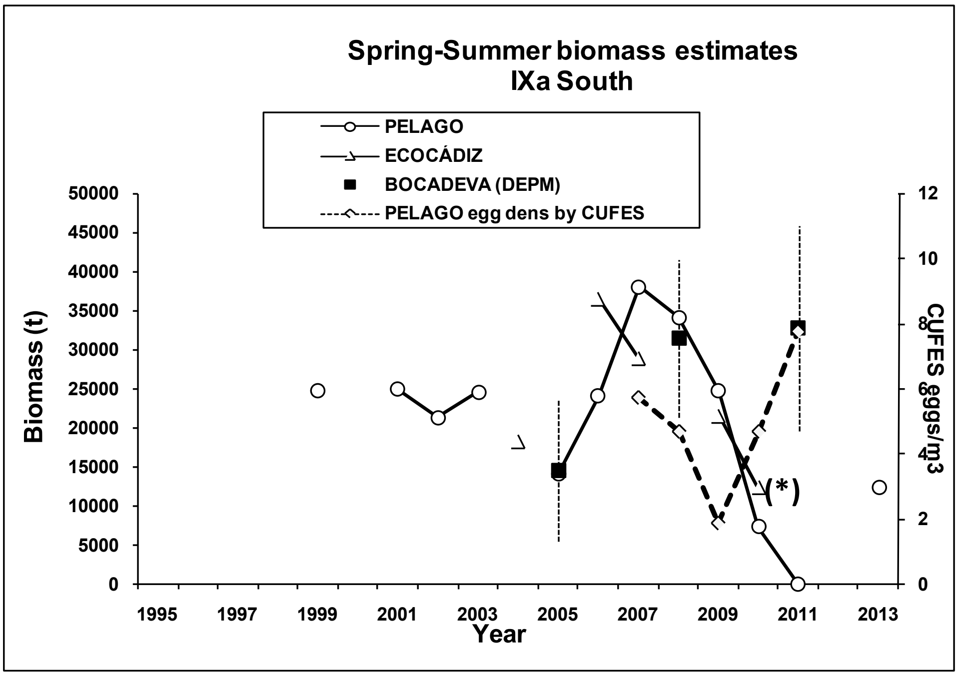


Figure 4.5.2.2. Anchovy in División IXa. Anchovy in Sub-division IXa-South. Information used in the Qualitative (Updated) Assessment. Top: total annual landings in Division IXa differentiated between Sub-division IXa South (Algarve + Gulf of Cádiz) and remaining Sub-divisions. Middle: standardised fishing effort (fishing days) exerted by the Spanish purse-seine fleet in the Sub-division. Bottom: standardised anchovy LPUE (tonnes/fishing day) of the same fleet.



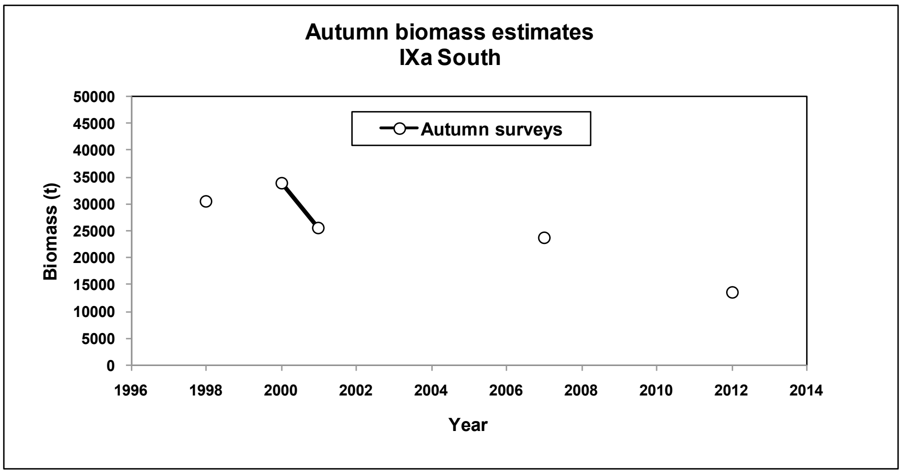


Figure 4.5.2.2 (Cont…). Anchovy in División IXa. Anchovy in Sub-division IXa-South. Information used in the Qualitative (Updated) Assessment (cont'd). Top: available biomass estimates from research surveys series sampling the Sub-division in spring/summer used for comparative purposes. Anchovy egg densities sampled by CUFES during the most recent *PELAGO* surveys are also shown for comparison with their respective population biomass acoustic estimates (by chance this value is overlaid with the DEPM estimates for 2011 despite of having independent axis for reference). No CUFES eggs data available for the 2013 survey. Asterisk denotes that the 2010 *ECOCÁDIZ* survey only partially explored the whole survey area. There are no available estimates in 2012.Bottom: available biomass estimates from research surveys series sampling the Sub-division in autumn. *SARNOV* (1998, 2000, 2001, 2007) and *ECOCÁDIZ-RECLUTAS* (2012) surveys have been merged in one only series.

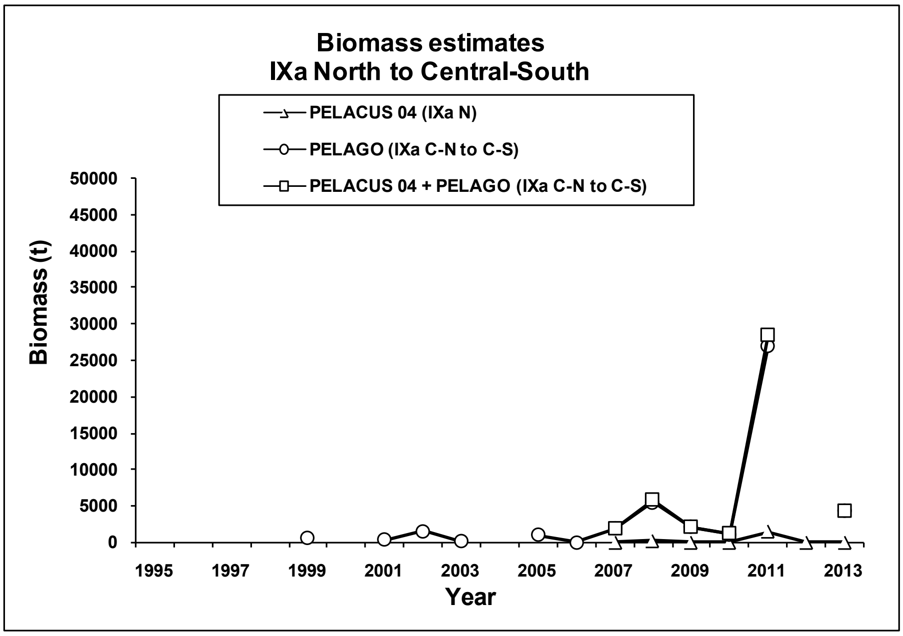


Figure 4.5.2.3. Anchovy in División IXa. Anchovy in Sub-divisions IXa-North to Central-South (Western Iberian Atlantic façade). Information used in the Qualitative (Updated) Assessment: total annual landings from Sub-divisions and the whole region (see Figure 4.5.2.1), and available biomass estimates from research surveys series sampling the Sub-divisions used for comparative purposes. For 2012 the only available estimates is the one from the *PELACUS 04* survey for IXa North.

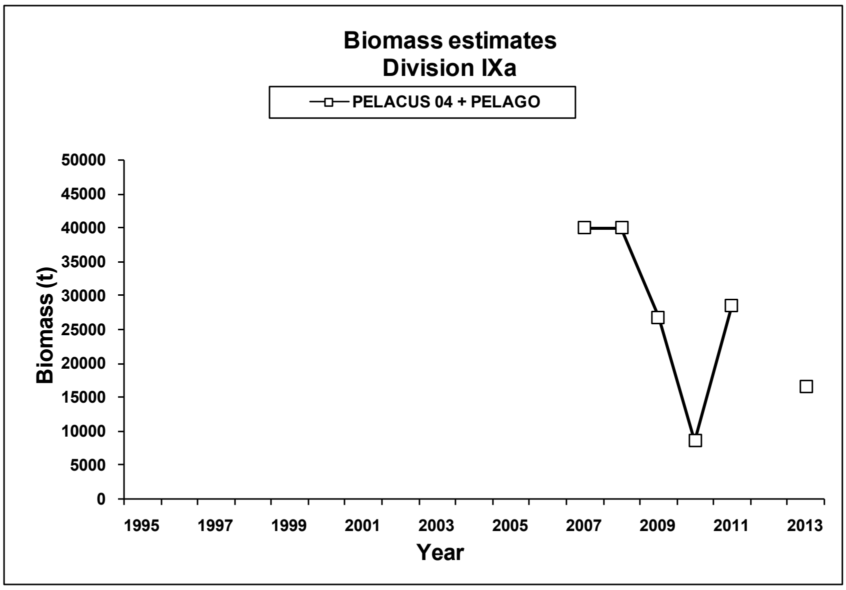
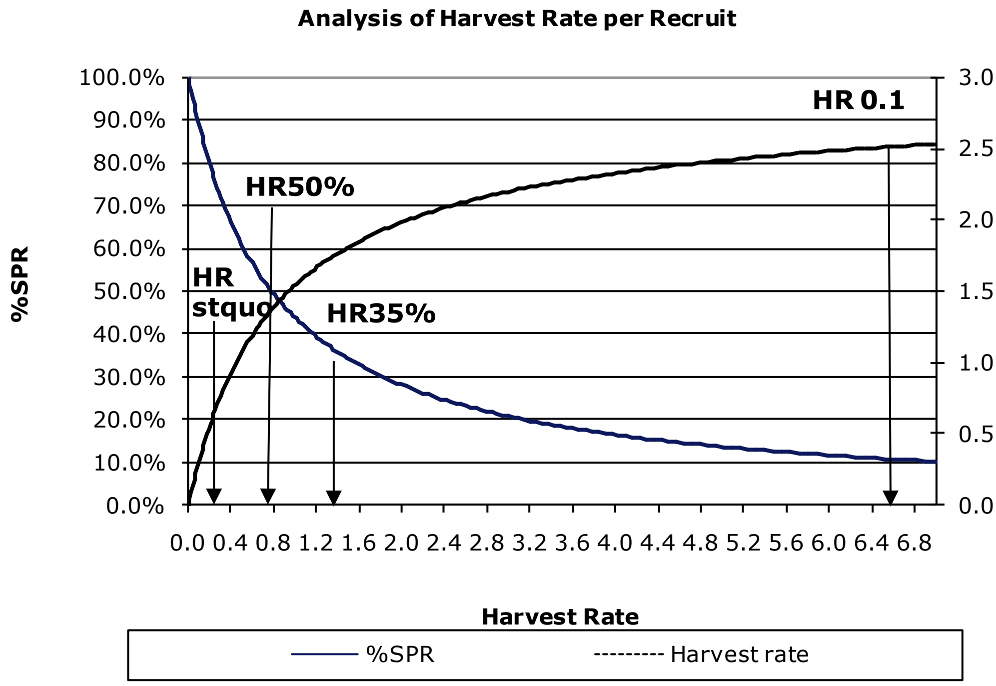


Figure 4.5.2.4. Anchovy in División IXa. Information used in the Qualitative (Updated) Assessment of the whole Division: total annual landings (see Figure 4.5.2.1) and available biomass estimates from research surveys series sampling the Division. For consistency, when merging estimates for the whole Division, only spring surveys (both *PELACUS 04* and *PELAGO*) have been considered.



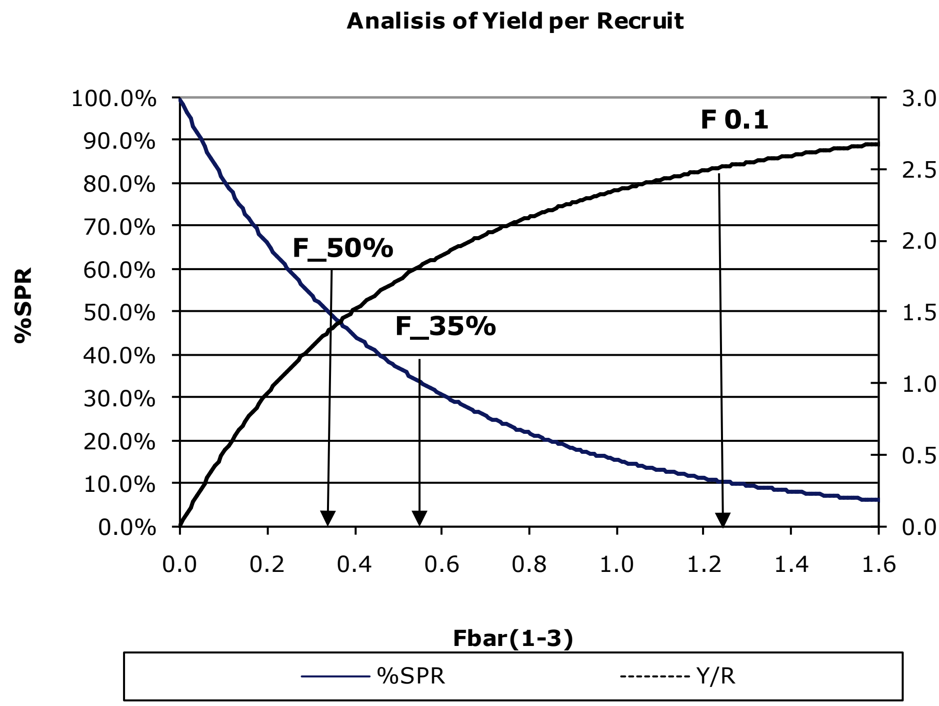


Figure 4.7.1. Anchovy in División IXa. Sub-division IXa South. Plots with the reference points for F and HR corresponding to the selectivity at age fitted with a presumed F at age 1 = 0.6

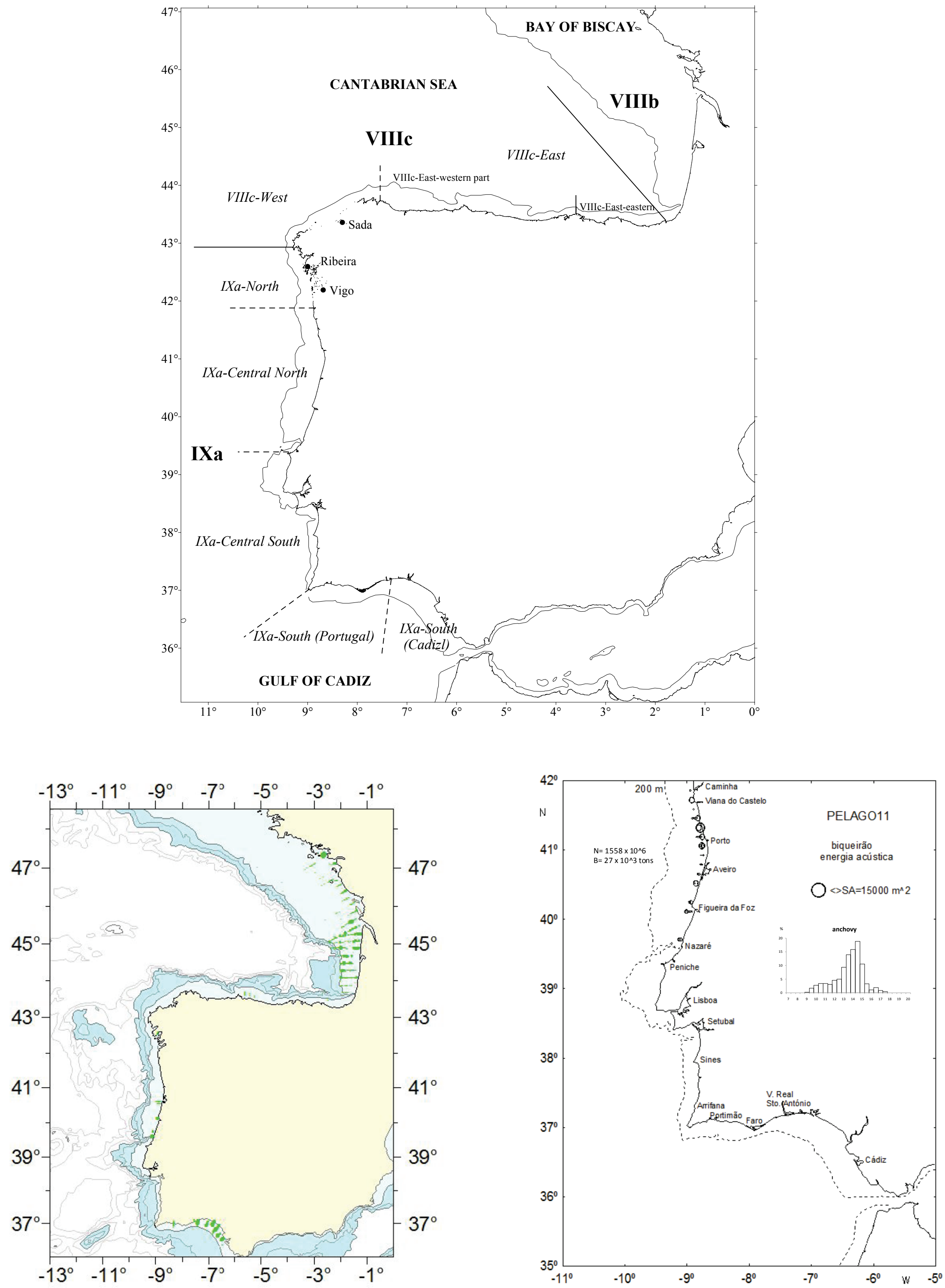


Figure 4.8.1.1. Anchovy in División IXa. A) Geographical distribution of Sub-divisions. B) Usual distribution of the anchovy populations throughout the Division as derived from the combined 2007 acoustic surveys off Iberia and the Armorican shelf (from ICES, 2009b). C) Spatial pattern of the anchovy abundance in the Division from the 2011 spring Portuguese acoustic survey.

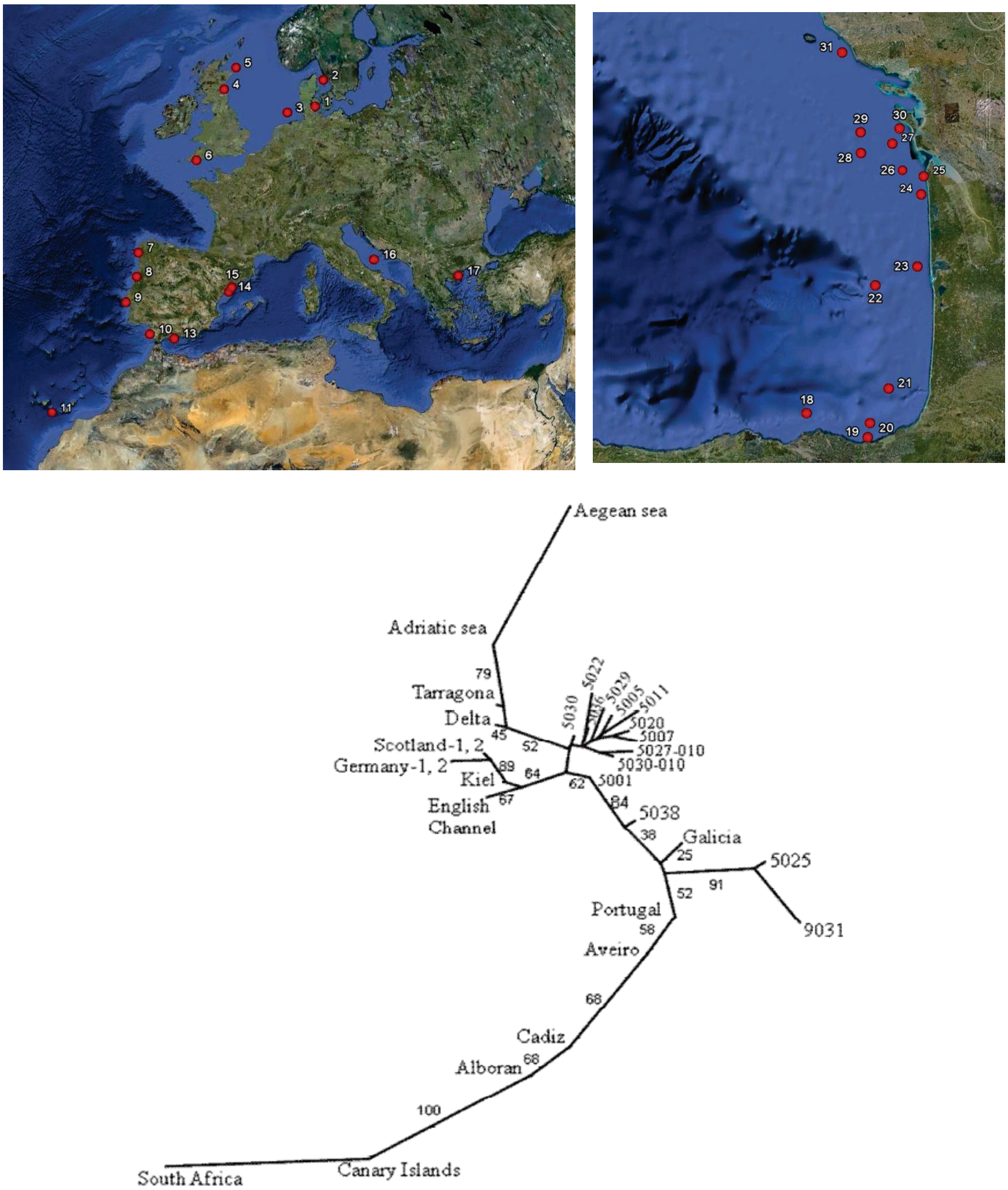


Figure 4.8.1.2. Anchovy in División IXa. Results from Zarraonandía's (2011) studies on genetic structure of European anchovy populations using single nucleotide polymorphisms (SNP). Upper row: geographical location of the analysed samples. Lower figure: Neighbour-Joining (NJ) dendrogram based on Reynolds distances among all the analyzed localities. Topological confidence obtained by 1,000 bootstrap replicates.

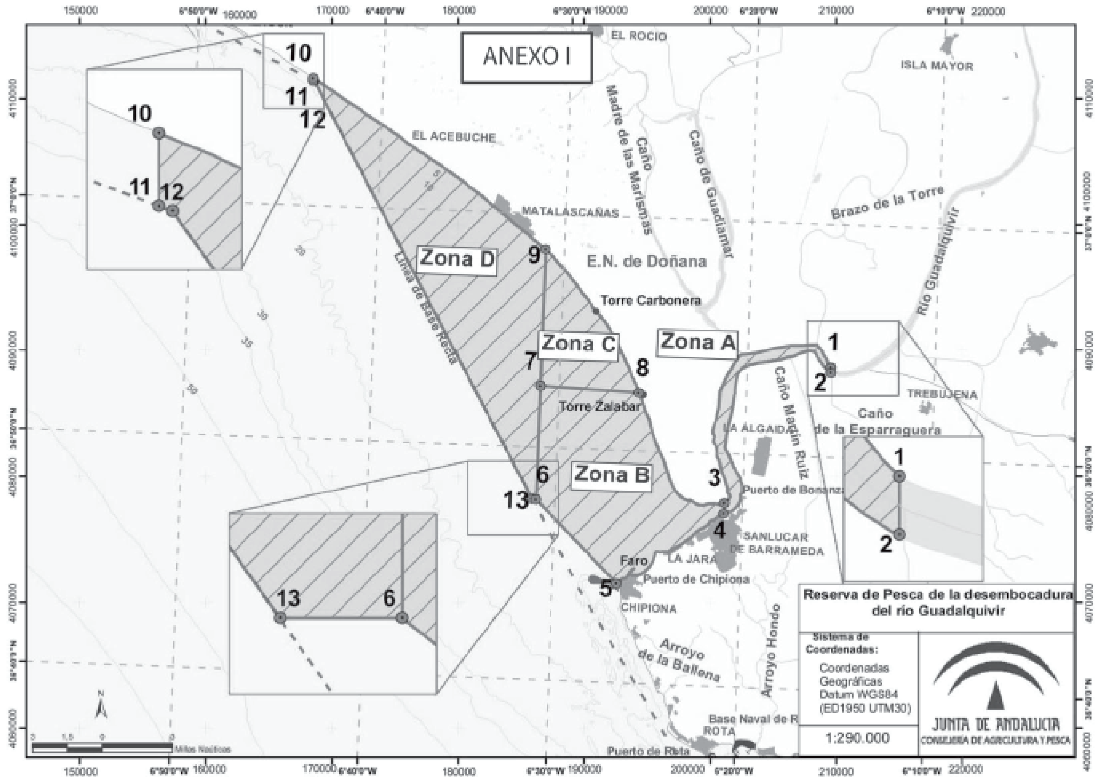


Figure 4.8.2.1. Anchovy in Division IXa. Sub-division IXa-South. Limits of the Fishing Reserve off the Guadalquivir river mouth (Spanish waters of the Gulf of Cadiz).

5 Sardine general

5.1 The fisheries for sardine in the ICES area

5.1.1 Catches for sardine in the ICES area

Commercial catch data for 2012 were provided by Portugal, Spain, France, Netherlands, Ireland and UK (England and Wales) (**Table 5.1.1.1**). Total reported catch was 83 953 tonnes, divided as follows: 38% of the catches by Portugal, 36% by Spain and 20% by France. The remaining 6% of catches are reported by Netherlands, England and Wales. Catches in VIIIc and IXa amount to 55% of the total sardine catches. It should be noted that fishing activities are limited in both Spain and Portugal, while there are no catch regulations in place in the other countries. In 2012, there was a 22% decrease with respect to the total 2011 sardine catches reported in European waters. Portugal showed a 44% decrease while Spain showed the same amount of catches with respect to 2011. Landings in France showed a 11% decrease and catches from England, Wales and Netherlands have respectively multiplied their catches 6 and 2.9 times. Overall it seems there was in 2012 an increase of catches in Northern areas (VIIIa and VII) while Southern areas had lower catches.

Table 5.1.1.1: Sardine general: 2012 commercial catch data from the ICES area, available to the Working Group.

Divisions	UK (Engl&Wal)	Ireland	France	Spain	Portugal	Netherlands	Total
IVa							
IVb						1	1
IVc			2			40	42
VIa							
VIIa		8.1					8
VIIb							
VIIc							
VIId	86		283			557	926
VIIe	2781		161			422	3364
VIIf	1555					460	2015
VIIg		<1					
VIIh	1						1
VIIi							
VIIj		<1					
VIIIa			15952				15952
VIIIb				14948		5	14953
VIIIc			6	4917			4923
VIIId							
VIIIe							
IXaN				4154	19647		23801
IXaCN					9045		9045
IXaCS							
IXaS-Alg				6031	2891		8922
IXaS-Cad							
Total	4423	8	16404	30050	31583	1485	83953

6 Sardine in divisions VIIIabd and subarea VII

6.1 Population structure and stock identity

Sardine in Celtic Seas (VIIabcfgjk), English Channel (VIId, VIIe, VIIh) and in Bay of Biscay (VIIIabd) are considered to belong to the same stock from a genetic point of view. Therefore, the sardine stock in VIIIabd and VII can be considered as a single stock unit with substantial mixing between areas.

There are evidence from landings that some fish coming from VIIIa are caught in VIIh and VIIe and vice versa. Dutch vessels which operates in the English Channel and North sea sometimes declare catches in VIIIa. Major landings occurs in both VIIIabd and near and in the English Channel (VIId, VIIe, VIIf, VIIh) area. Less landings occur in other VII areas although they still are of one or two thousands tons.

Information is almost inexistent regarding biological sampling of sardine in the English Channel and inexistent in the Celtic Sea. From the few information available, it appears that the caught sardines tend to be bigger in the Channel.

From the modelling point of view, the lack of commercial sampling in area VII, survey, biological information in contrast to the richness of the datasets available for the Bay of Biscay does not allow the use of a single assessment method for the whole area.

This stock was benchmarked at WKPELA in 2013 by ICES and while it was considered to be a single stock unit,

it was decided to divide this stock in two "substock": VIIIabd and VII to take account of the regional differences in terms of environment, fisheries and data availability. No analytical assessment is currently usable for these regions therefore the assessment and advice are based on trends from several indicators defined in the stock annex.

6.2 Input data in VIIIabd and VII

Official landings per country reported to ICES for the whole area are in available in **table 6.2.1.1**.

6.2.1 Catch data

Divisions VIIIabd

An update of the French and Spanish catch data series in Divisions VIIIa and VIIIb (from 1983 and 1996 for France and Spain, respectively) including 2012 catches was presented to this year´s WG (**Table 6.2.1.2**). Spanish catches are taken by purse seines from the Basque Country operating only in division VIIIb. Spanish landings peaked in 1998 and 1999 with almost 8 thousand tonnes but have decreased until 2010 to below 1 thousand tonnes. In 2012, 14948 tonnes were landed which is the historical record of the Spanish landings. The Spanish fishery takes place mainly during March and April and in the fourth quarter of the year.

French catches have increased along the series, with values ranging from 4 367 tonnes in 1983 to 21 104 tonnes in 2008 with some fluctuations; 15 952 tonnes were landed in 2012.

A total of 90% of the catches are taken by purse seiners while the remaining 10% is reported by pelagic trawlers (mainly pair trawlers). A substantial part of the French catches originates in divisions VIIh and VIIe, but these catches have been assigned to division VIIIa due to their very concentrated location at the boundary between VIIIa, VIIh and VIIe.

Both purse seiners and pelagic trawlers target sardine in French waters. Average vessel length is about 18 m. Purse seiners operate mainly in coastal areas (<10 nautical miles) while trawlers are allowed to fish within 3 nautical miles from the coast. Both pair trawlers and purse seiners operate close to their base harbour when targeting sardine. The highest catches are taken in the summer months. Almost all the catches are taken in south-west Brittany.

Numbers by length-class for divisions VIIIa,b by quarter are shown in **Tables 6.2.1.3** and **6.2.1.4** for France and Spain (only VIIIb), respectively. While French catches in divisions VIIIa and VIIIb are constituted by fish of a wide range of sizes with a peak at 20 cm length, sardine taken by Spanish vessels show a narrower range of sizes but with a peak at similar length size.

Subarea VII

Most of the catches are concentrated close to or in the English Channel (VIId, VIIe, VIIf, VIIh) with major landings from France and Netherlands, other catches being taken by England & Wales and on occasions by Ireland. No information were available from other countries operating in that subarea. Catches have substantially oscillated with time and between countries (**Table 6.2.1.5**) from 12000 to 3800 tons. In 2012, the catches were 6314t with England catching most of it (4423t).

No additional information was available such numbers by length-class due to lack of monitoring of the fisheries operating in that subarea.

6.2.2 Surveys in Divisions VIIIabd

6.2.2.1 DEPM survey in in Divisions VIIIabd

All the methodology for the survey is described in detail in the stock annex - Bay of Biscay Anchovy (Subarea VIII). A detailed report of the survey 2013 is attached as Santos. M et al. – WD 2013.

Total egg abundance for sardine was estimate as the sumof the numbers of eggs in each station multiply by the area each station represent. This year estimate is 5.5E+12 eggs, at same levels as last year. The abundance of sardine was scarce in relation with the historical series (**Fig.6.2.2.1.1**, **Table 6.2.2.1.1**), all the eggs where inside the 100m depth in the French platform, no eggs were encountered in the cantabrian region (**Fig. 6.2.2.1.2**). In PairoVET a total of 213 (43%) stations had sardine eggs with an average of 8 eggs per 0.1 m-2 per station and a maximum of 301 eggs 0.1m-2.

The historical series of egg abundances distribution is shown in **Figure 6.2.2.1.3**.

6.2.2.2 PELGAS acoustic survey in Divisions VIIIabd

The French acoustic survey PELGAS takes place every spring in the Bay of Biscay on board the R/V Thalassa with the main objective of studying the abundance and distribution of pelagic fish in the Bay of Biscay and to study the pelagic ecosystem as a whole. In 2013, PELGAS took place from the 24th April to 5th June and detailed objectives, methodology and sampling strategy are described in the WD- Duhamel et al (2013) presented in this group.

Target species were anchovy and sardine but both species were considered in a multi-species context.

Sardine was distributed mixed with anchovy front of the Gironde (small fishes for both species) and mixed with sprat in the Loire plume. Then, sardine appeared pure along the Landes’s coast, where a upwelling occured, due to the regular Northern wind. Sardine was also present close to the surface in the Northern part of the bay of Biscay, along the shelfbreak, sometimes mixed with mackerel.(see **figure 6.2.2.2.1**) .

As usual, sardine shows a bimodal length distribution, the first one (about 15 cm, corresponding to the age 1, and very well present this year along the coast) and the second about 19 cm, which is mainly constituted by the 2 and 3 years old (see **figure 6.2.2.2.2**).

The series of age distribution in numbers since 2000 are shown in **figure 6.2.2.2.3**. We can observe that we can follow cohorts (i.e. the very low 2005 age class, or very high 2008 age class). 2003 and 2007 were atypical years in terms of environmental conditions and therefore fish (and particularly sardine) distributions.

The high abundance of age 1 (69% and 8 billions fishes) gives the impression that a very good recruitment occurred this year, maybe the best of the whole PELGAS serie.

The biomass estimate of sardine observed during PELGAS13 is 407 740 tons, which is a bit upper than the average level of the PELGAS series, and constituting a new increase of the biomass (**figure 6.2.2.2.4**). It must be remarked that these survey don't cover the total area of potential presence of sardine. It is possible that some years, this specie could be present up to the North, in the Celtic sea, SW of Cornouailles or Western Channel where some fishery occurs, apparently more and more.

6.2.3 Biological data

6.2.3.1 Catch numbers at length and age

Tables 6.2.3.1.1 and 6.2.3.1.2 shows the catch-at-age in numbers for each quarter of 2012 for French and Spanish landings respectively in VIIIabd. For France, fish of age 1 dominated the fishery while for Spain, age 4 dominated the fishery in 2012. This difference is related to the absence of catch from Spain in quarter 3 as the Spanish vessels are targetting thuna while the French fleets are still fishing sardine.

No data were available for VII.

6.2.3.2 Mean length and mean weight at age

Mean length and mean weight at age by quarter in 2012 are shown in **Tables 6.2.3.2.1-6.2.3.2.4** for both French and Spanish landings in VIIIabd.

No data were available for VII.

6.2.4 Exploratory assessments

6.2.4.1 Trends of indicators in VIIIabd.

Bay of Biscay has the most available data in the stock unit. However, with most of them starting in 2000-2002, the benchmark WKPELA concluded that for the time being times series were still too short to be used by an assessment model. It was rather recommended to use indicators in order to assess the state of the stock.

a) comparison between PELGAS (acoustic) and BIOMAN (egg count/DEPM)

Time series of biomass estimates from the PELGAS acoustic survey are compared against the time series of number of eggs from the BIOMAN (DEPM) survey. Both indices show very similar trends except for 2001 (correlation between indices is r^2=0.67 if 2001 is removed, 0.49 if included). (**table 6.2.4.1.1**, **figure 6.2.4.1.1**).

Overall, the biomass has increased over the period covered by the time series but with substantial oscillations of higher and lower levels of biomass. The last big cycle peaked in 2009-2010. Following years were lower but in the middle of the range of biomass for the period 2000-2013 at an average of 307t for 2012 and 2013.

For 2013, the Pelgas survey estimates biomass to be close to 408 kt tons (+98% increase in comparison to 2012) while preliminary egg counts from DEPM suggests a decrease of 3%.

The time series of biomass estimates suggests generally low harvest rates as the portion of landed biomass rarely exceed 10%.

b) stock structure.

Stock structure at age is available from both catches from Spanish and French fleets and estimates from the PELGAS survey for VIIIabd. Similar information is not available from subarea VII.

Times series of weight at age and number at age for both commercial fleets and surveys are provided in **tables 6.2.4.1.2a&b and 6.2.4.1.3a&b**.

The composition of catches at age for the commercial fleets (**figure 6.2.4.1.2**) is variable through time. In 2011 and 2012, catches have been mainly made from age 2-3 individuals. The composition of catches at age for the PELGAS survey (**figure 6.2.4.1.3 and 6.2.4.1.4**) show the dominance of ages 1 and 5 in 2012-2013.

Recruitment in 2013 is the highest at 8,3 millions of individuals and is 91% higher than in 2012.

c) Catch curve analysis on survey and commercial fleets.

Catch curve were derived from the whole times series of catch at age in VIIIabd from both commercial fleets and PELGAS survey (**figure 6.2.4.1.5**). Average total mortality over the whole time series is estimated to be equal to 0.462 for the commercial fleet and 0.604 for the PELGAS survey.

Total mortality at age in 2013 was also estimated from both source commercial fleet and survey.

For commercial catches (**figures 6.2.4.1.6**.), ages 1, 2 and 5 are below their respective average over the time series while ages 4 and 6,7,8 are above. Overall, the average total mortality (total mortality at age weighted by number of individuals) for 2012 was estimated to be 0.454. This is slightly below the the value of the average (0.462).

Total mortality at age estimated from the PELGAS survey (**figure 6.2.4.1.7**) shows age 1,2,3 and 8 above their respective average and ages 5,9 below. Ages 2,4,7 are close to the average values. Overall, total mortality is estimated to be 0.576 for 2012 which is below the average of the time series (0.604).

Assuming a constant mortality at age of M=0.33, considering survey data are more representative of true stock structure in terms of catchability, a total mortality close to 0.6 suggests that fishing mortality F (Z=F+M) is around or slightly less than M. Therefore the fishery is likely to be sustainable.

6.2.4.2 Trends on landings in subarea VII based on the WKLIFE framework

As only catch and few efforts information are available for subarea VII, it is impossible to use any assessment model for the time being.. WKLIFE (2012) proposed alternate solution for data-limited stocks based on DCAC (Depletion Catch curve Analysis) which proven at WGHANSA 2012 to be not adequate given the lack of trends and out of range level of natural mortality assumption. Since the working group had readily only catch data, this substock is considered as a category 4 stock (catch only).

The overal recent trend in landings in subarea VII is a decrease of catch from 2004 in comparison to previous years (**figure 6.2.4.1)** . It is worth noting that since 2004 this subarea almost evolve in opposite to the neighboring landings in the Bay of Biscay. The opportunistic nature of the fisheries and the mixing between VII and VIII makes difficult any interpretation of this decrease. It is also known that the stock seems to move north therefore the decrease might not be related to a lower abundance of fish but most likely a lower effort on sardine.

6.2.5 Short term predictions

Due to the exploratory nature of the assessment, no predictions have been carried out. This stock is due for benchmark in 2013 and a proper prediction procedure will be established.

6.2.6 Reference points and harvest control rules for management purposes

No reference points, TACs and no harvest control rules are currently implemented for this stock.

6.2.7 Management considerations

There are no management objectives for these fisheries and there is no international TAC. Catch are mainly taken by France and Spain in VIIIabd and by France, Netherlands and United Kingdom in VII. The absence of sampling program in VII makes any attempt to analytically assess this stock impossible. If a sampling program starts, it will also take several years before having some sufficiently long time series of data. It is therefore recommended that a proper sampling program should be implemented to monitor the sardine fishery in subarea VII.

Table 6.2.1.1: Official landings reported to ICES (1989-2013).

	Subarea VII								Divisions VIIIa,b,d								Total catch
	France	United Kingdom	Netherlands	Ireland	Germany	Denmark	Lithuania	Spain	France	Spain	Netherlands	Ireland	United Kingdom	Denmark	Germany	Lithuania	
1989	1219	1660	11			4667			8811								16368
1990	1128	2078	6		107	6113			8543								17975
1991	1963	2952			8	4462			12482	35							21902
1992	1777	4493	41		4	17843			8847	43							33048
1993	1135	4917	109			13395			8805	45				308			28714
1994	1285	2081	20		2	20804			8604								32796
1995	1282	7133	107		66	9603			9877		24						28092
1996	1563	7304	48			1396			8604								18915
1997	3346	7280	411		13	1124			10706		26						22906
1998	1974	6873	1647	192	100	14316			9778	873					68		35821
1999	0	4815	5166	3195	146	3490		8	0	2384				124	11		19339
2000	1667	4353	6586	2577	436	1682			11301	1989	34				38		30663
2001	9625	10375	6608	2427	454				10982		333				135		40939
2002	8642	7858	1905	5728	224			10	12963	2881	23	19	276		4		40533
2003	12546	4358	6897	3765	25				10631	2408	68	1700	68				42466
2004	8882	2681	2187	2444	109	742			9971	1853	6	1401					30276
2005	15363	3631	2231	1435	274			5	11787	1203	1	974			54		36958
2006	17724	1925	2287	1257	481		17	2	9810	839	2	49		12	78	5	34489
2007	11217	2654	1106	14		4			13966	706				48			29715
2008	10491	3470	2073	236	42	54			12111	1989			1	39			30507
2009	14781	2541	3406	33					20743	602							42106
2010	8725	2521	6645	25	106	13			16087	2948							37070
2011	707	3604	513	983	22	3			17925*	5283*	5						29045
2012	444	4423	1439	8					15952*	14948*							37214

* WG estimates for 2011 and 2012

Table 6.2.1.2: Sardine general: Landings by France (1983-2012) and Spain (1996-2012) in ICES divisions VIIIa, VIIIband VIIId as estimated by the WG.

Year	Catch (tonnes)	
	France	Spain*
1983	4367	n/a
1984	4844	n/a
1985	6059	n/a
1986	7411	n/a
1987	5972	n/a
1988	6994	n/a
1989	6219	n/a
1990	9764	n/a
1991	13965	n/a
1992	10231	n/a
1993	9837	n/a
1994	9724	n/a
1995	11258	n/a
1996	9554	2053
1997	12088	1608
1998	10772	7749
1999	14361	7864
2000	11939	3158
2001	11285	3720
2002	13849	4428
2003	15494	1113
2004	13855	342
2005	15462	898
2006	15916	825
2007	16060	1263
2008	21104	717
2009	20627	228
2010	19485	642
2011	17925	5283
2012	15952	14948

* all landings from division VIIIb

n/a = notavailable

Table 6.2.1.3: Sardine general: French catch length composition (thousands) by ICES divisions VIIIa,b in 2012.

Length * (half cm)	Quarter 1	Quarter 2	Quarter 3	Quarter 4	All year
9			66695		66 695
9.5			233432.3	55598	289 030
10			166 737	55 598	222 335
10.5			200 085	41 978	242 063
11			200 085	12 050	212 135
11.5			166 737	12 050	178 788
12		40 660	133 390	45 412	219 463
12.5	66 401		66 695	312 117	445 213
13	304 126	83 964		159 868	547 957
13.5	438 794	251 891		112 886	803 571
14	538 448	904 395	66 695	90 354	1599 893
14.5	435 616	1405 142	33 347		1874 106
15	659 609	3025 008	2246 768	57 815	5989 200
15.5	484 018	4808 614	13463 168	154 174	18909 974
16	358 213	4152 538	23570 430	243 311	28324 492
16.5	263 050	4345 662	21460 518	482 188	26551 418
17	358 998	4899 668	14893 232	322 835	20474 733
17.5	614 178	3344 445	10138 421	596 214	14693 258
18	713 632	2378 433	8916 815	613 093	12621 973
18.5	526 645	1214 805	9014 737	337 717	11093 904
19	1073 880	1427 439	10051 449	811 603	13364 371
19.5	864 694	4388 379	15298 509	915 402	21466 984
20	1739 456	5226 215	13449 338	978 571	21393 579
20.5	2368 459	5759 578	9650 426	802 469	18580 931
21	1536 335	6293 111	9753 284	1660 535	19243 265
21.5	606 006	5866 488	6821 178	882 167	14175 839
22	700 854	4907 179	7209 501	691 273	13508 808
22.5	274 972	3306 412	4220 760	838 620	8640 763
23	317 610	2346 765	2543 783	345 637	5553 794
23.5	258 687	960 156	787 059	123 246	2129 148
24	78 563	213 481	1049 412		1341 456
24.5	19 641		262 353	55 598	337 592
25	19 641		787 059		806 700
25.5	19 641				19 641
26					
26.5					
27					
27.5					
28					
28.5					
29					
Total	15640 167	71550 426	186922 099	11810 378	285923 070
Averagelength	18.9	19.0	18.4	19.4	18.6
Catch (t)	986	4362	10113	2464	17925

Table 6.2.1.4: Sardine general: Spanish catch length composition (thousands) by ICES divisions VIIIb in 2012.

Length * (half cm)	Quarter 1	Quarter 2	Quarter 3	Quarter 4	All year
10					
10.5					
11					
11.5					
12	123				123
12.5	564				564
13	886				886
13.5	1 537	104			1 641
14	1 011				1 011
14.5	1 614	155		61	1 831
15	863	207		38	1 108
15.5	1 947	414		34	2 395
16	2 004	259		45	2 308
16.5	2 809	466		159	3 433
17	2 579	259		603	3 441
17.5	4 222	466		2 043	6 731
18	3 625	182		2 954	6 760
18.5	4 884	406		4 884	10 174
19	4 391	532		6 747	11 670
19.5	6 652	766		9 383	16 800
20	7 572	652		13 656	21 881
20.5	8 716	1 141		15 112	24 969
21	7 270	558		18 016	25 843
21.5	5 918	368		16 594	22 880
22	3 943	101		16 405	20 449
22.5	2 507	51		9 909	12 468
23	1 284			6 433	7 717
23.5	571			2 502	3 073
24	228			1 104	1 333
24.5	77			95	172
25					
25.5					
26					
26.5					
27					
27.5					
28					
28.5					
29					
29.5					
30					
30.5					
31					
Total	77 798	7 087		126 777	211 661
Averagelength	19.2	18.7		20.9	20.2
Catch (t)	4755	400		9793	14948

Table 6.2.1.5: Sardine landings (tons) in ICES subarea VII in 2011.

Year	France	Netherlands	UK	Ireland	Total
1996	1563	48	7304	0	8915
1997	3346	411	7280	0	11037
1998	1974	1647	6873	192	10686
1999	119	5166	4815	3195	13295
2000	1594	6586	4353	2577	15110
2001	2313	6608	10375	2427	21723
2002	2232	1905	7858	5728	17723
2003	5318	6897	4358	2015	18588
2004	3266	2187	2681	1567	9701
2005	4315	2231	3631	461	10638
2006	5156	2287	1925	1211	10580
2007	4418	1106	2654	14	8192
2008	5195	2073	3470	236	10975
2009	6674	3406	2541	33	12654
2010	2787	6645	2521	25	11978
2011	2515	513	3603	983	7615
2012	444	1439	4423	8	6314

Table 6.2.2.1.1: Bay of Biscay sardine:Historical series of sardine egg abundance. PIL egg (sardine egg abundances (number of eggs)), pos.area (positive area), tot.area (total area)

Year	PIL egg	pos area	tot area	% pos area
1999	1.30E+12	26,679	59,193	45
2000	5.00E+12	40,139	52,212	77
2001	9.20E+11	14,547	51,629	28
2002	8.30E+12	39,112	50,951	77
2003	2.80E+12	22,878	47,927	48
2004	9.20E+12	37,289	49,446	75
2005	1.10E+13	38,979	50,202	78
2006	3.80E+12	23,376	45,413	51
2007	2.30E+12	16,710	45,499	37
2008	9.40E+12	20,235	46,501	44
2009	7.53E+12	34,746	60,733	57
2010	1.06.E+13	36,361	61,940	59
2011	4.50.E+12	22,851	98,405	23
2012	5.68E+12	20,054	80,381	25
2013	5.48E+12	25,423	77,838	33

Table 6.2.3.1.1: French 2012 landings in ICES division VIIIb:

Catch in numbers (thousands) at age.

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	WholeYear
0			2215	886	3101
1	3610	18965	117828	4012	144414
2	2553	13109	18817	1428	35906
3	2912	9145	19372	1818	33247
4	4662	19261	18245	2373	44541
5	1280	7713	5118	726	14836
6	318	1788	2589	312	5008
7	132	690	1338	161	2321
8	129	731	456	70	1386
9	45	149	944	25	1163
10					
11					
12					
13					
Total	15640	71550	186922	11810	285923
Catch (Tons)	924	4260	10026	742	15952

Table 6.2.3.1.2: Sardine general: Spanish 2012 landings in ICES division VIIIb:

Catch in numbers (thousands) at age.

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	WholeYear
0			0	1240	1240
1	12213	1397	0	10320	23930
2	14558	1398	0	29534	45491
3	8775	821	0	32120	41716
4	29189	2646	0	38170	70005
5	8662	681	0	8939	18282
6	2350	102	0	5701	8153
7	1829	41	0	795	2665
8	140	0			140
9	83				83
10					
11					
12					
13					
Total	77798	7087	na	126819	211704
Catch (Tons)	4755	400	0	9793	14948

Table 6.2.3.2.1: French 2012 landings in divisions VIIIa and VIIIb:

Mean length (cm) at age.

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	WholeYear
0			12.5	12.4	12.5
1	14.8	15.7	17.2	18.1	17.0
2	18.2	17.7	19.2	19.4	18.6
3	20.0	20.1	20.2	20.5	20.2
4	20.6	21.0	21.5	21.6	21.2
5	21.6	21.9	21.8	21.9	21.8
6	22.7	22.5	23.4	23.2	23.0
7	23.3	23.0	22.5	22.2	22.7
8	23.1	22.7	23.0	22.7	22.8
9	23.6	23.0	24.8	23.5	24.5
10					
11					
12					
13					
14					

Table 6.2.3.2.2: French 2012 landings in divisions VIIIa and VIIIb:

mean weight (kg) at age.

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	WholeYear
0			0.016	0.015	0.015
1	0.025	0.031	0.040	0.047	0.039
2	0.048	0.044	0.056	0.058	0.051
3	0.063	0.065	0.065	0.069	0.065
4	0.070	0.073	0.080	0.080	0.076
5	0.081	0.083	0.083	0.084	0.083
6	0.094	0.091	0.102	0.100	0.097
7	0.102	0.097	0.091	0.087	0.093
8	0.098	0.094	0.097	0.093	0.095
9	0.105	0.098	0.121	0.104	0.117
10					
11					
12					
13					
14					

Table 6.2.3.2.3: Spanish 2012 landings in ICES division VIIIb:

Mean length (cm) at age.

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	WholeYear
0				17.2	17.2
1	15.1	15.7		19.2	16.9
2	18.1	18.0		20.5	19.7
3	19.7	19.5		21.1	20.8
4	20.7	20.5		21.8	21.3
5	21.3	20.8		22.2	21.7
6	22.1	21.6		22.1	22.1
7	22.7	21.8		22.9	22.8
8	24.3				24.3
9	24.4				24.4
10					
11					
12					
13					
14					

Table 6.2.3.2.4: Sardine general: Spanish 2012 landings in ICES division VIIIb: mean weight (kg) at age.

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	WholeYear
0				0.040	0.040
1	0.026	0.030		0.057	0.040
2	0.047	0.046		0.070	0.062
3	0.062	0.060		0.077	0.073
4	0.072	0.069		0.085	0.079
5	0.079	0.073		0.090	0.084
6	0.088	0.082		0.089	0.088
7	0.097	0.085		0.100	0.098
8	0.120				0.120
9	0.121				0.121
10					
11					
12					
13					
14					

Table 6.2.4.1.1: Survey indices from Pelgas (acoustic) and Bioman (DEPM) surveys in VIIIa,b,d. Landings in VIIIa,b,d and VII.

	Survey			Landings	
Year	PELGAS	PELGAS	BIOMAN	VIIIabd, VII	% of landed
	age 1 individuals	Biomass	egg count (billions)	(tons)	biomass
1999			1.3	41592	
2000	1 276 312	376 442	5	33281	8.8
2001	1 280 080	383 515	0.92	37446	9.8
2002	3 458 311	563 880	8.3	36521	6.5
2003	160 136	111 234	2.8	37055	33.3
2004	2 997 203	496 371	9.2	26887	5.4
2005	2 613 794	435 287	11	28306	6.5
2006	605 847	234 128	3.8	27951	11.9
2007	631 471	126 237	2.3	25571	20.3
2008	3 432 039	460 727	9.4	32890	7.1
2009	6 111 475	479 684	7.53	33509	7.0
2010	1 511 640	457 081	10.6	32206	7.0
2011	1 435 411	338 468	4.5	30851	9.1
2012	3 257 929	205 627	5.68	37214	18.1
2013	8 334 258	407 740	5.48		

Table 6.2.4.1.2a: Weight at age (in kilograms) from French and Spanish commercial fleets in VIIIa,b,d.

AGE	0	1	2	3	4	5	6	7	8	9
2002	0.018	0.044	0.069	0.080	0.088	0.100	0.112	0.115	0.130	0.133
2003	0.019	0.054	0.080	0.091	0.101	0.111	0.117	0.129	0.132	0.124
2004	0.020	0.040	0.080	0.090	0.095	0.101	0.111	0.120	0.130	0.125
2005	0.018	0.047	0.081	0.089	0.094	0.097	0.105	0.110	0.119	0.133
2006	0.024	0.039	0.074	0.088	0.094	0.101	0.110	0.115	0.118	0.133
2007	0.032	0.053	0.081	0.087	0.099	0.104	0.109	0.120	0.123	0.131
2008	0.018	0.044	0.063	0.076	0.078	0.091	0.100	0.095	0.103	0.110
2009	0.032	0.038	0.062	0.073	0.086	0.087	0.096	0.098	0.100	0.115
2010	0.023	0.038	0.061	0.074	0.081	0.090	0.092	0.102	0.103	0.111
2011	0.028	0.043	0.066	0.074	0.082	0.090	0.096	0.100	0.113	0.115
2012	0.043	0.045	0.056	0.068	0.077	0.082	0.086	0.100	0.102	0.121

Table 6.2.4.1.2b: Weight at age (in grams) from the Pelgas acoustic survey in VIIIa,b,d

Age	1	2	3	4	5	6	7	8	9	10	11	13
PELGAS 00	35.05	54.74	69.15	76.46	84.82	89.93	98.83	110.20	105.00	112.90		117.40
PELGAS 01	41.28	58.85	76.83	83.84	93.68	96.92	103.40	105.40	112.70	121.00	119.90	
PELGAS 02	40.48	60.20	74.94	81.70	92.31	99.42	106.70	118.10				
PELGAS 03	53.35	68.04	73.15	78.11	86.04	93.33	88.74	96.09				
PELGAS 04	35.94	64.73	76.54	84.39	95.87	98.83	104.30	109.20	106.20			
PELGAS 05	34.44	63.45	73.29	79.62	84.88	88.96	90.04	105.40	109.50	98.35		
PELGAS 06	39.17	58.37	70.78	81.18	86.37	82.48	91.25	97.22	107.00	112.00	110.90	
PELGAS 07	37.55	65.96	71.77	79.05	84.02	94.45	100.40	96.93	101.30	114.90		
PELGAS 08	33.44	60.33	71.10	75.18	83.82	92.84	90.45	95.67	99.48	101.40	109.40	
PELGAS 09	29.51	57.13	73.62	81.28	83.26	88.35	95.67	91.44	96.50	106.67	82.00	
PELGAS 10	30.33	50.55	64.04	73.05	78.43	87.58	93.16	105.88	106.96	116.01		
PELGAS 11	27.37	50.13	58.69	69.84	78.35	83.00	84.28	108.17	105.38	108.33		
PELGAS 12	22.88	44.66	57.40	65.45	78.42	87.83	95.26	92.27	99.83			
PELGAS 13	21.16	44.33	55.82	68.30	77.42	84.27	89.28	99.10	113.27	89.17		

Table 6.2.4.1.3a: Catch at age (in numbers) from French and Spanish commercial fleets in VIIIa,b,d (Thousands)

CANUM	0	1	2	3	4	5	6	7	8	9
2002	3703	162938	67783	25016	15760	11127	7444	2157	1170	824
2003	4382	89475	62145	27447	16545	9657	6207	3334	1647	737
2004	22283	88306	50184	36191	15110	9388	2796	1328	632	306
2005	4114	91371	41479	29105	22998	17983	9190	5115	3167	1805
2006	8896	35588	84755	30337	21008	15204	9519	6946	3558	2807
2007	24017	66813	25930	59416	13095	14186	12178	7468	3582	2907
2008	3845	162408	71484	26645	42044	13223	11590	10818	5354	5062
2009	8535	117821	139899	50134	25636	24240	12465	9282	5517	1916
2010	1907	37905	107444	59131	18719	14837	22904	7452	8527	4811
2011	3938	42575	62666	118526	56833	8562	15571	5400	5518	3082
2012	3120	146755	46509	46419	71903	27064	6378	2880	1850	1195

Table 6.2.4.1.3b: Population at age estimates (in numbers) from the Pelgas acoustic survey in VIIIa,b,d

PELGAS	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
2000	1,276,312	1,559,347	1,083,847	721,738	551,465	218,657	152,984	132,676
2001	1,280,080	1,367,856	819,203	751,576	353,970	466,190	175,124	277,453
2002	3,458,311	3,585,189	1,115,098	566,798	162,725	85,013	38,003	9,120
2003	160,136	528,081	463,812	165,696	55,940	2,234	5,426	1,090
2004	2,997,203	2,029,661	1,606,397	706,117	467,766	283,692	95,817	61,324
2005	2,613,794	1,807,043	824,020	822,188	610,585	383,260	230,492	174,773
2006	605,847	2,819,592	274,996	90,287	42,056	38,918	13,436	16,260
2007	631,471	296,092	761,271	131,707	57,856	64,658	27,165	35,554
2008	3,432,039	1,549,493	383,747	1,478,305	301,616	223,603	241,521	373,181
2009	6,111,475	3,286,964	707,700	301,305	737,098	215,647	148,810	157,875
2010	1,511,640	5,227,578	1,558,567	267,859	125,992	122,739	27,877	41,082
2011	1,435,411	1,504,792	2,516,162	794,842	106,115	64,749	23,433	33,899
2012	3,257,929	1,129,668	833,824	1,158,709	340,656	77,427	54,120	43,030
2013	8,334,258	1,934,208	558,270	313,743	563,894	211,086	49,522	47,293

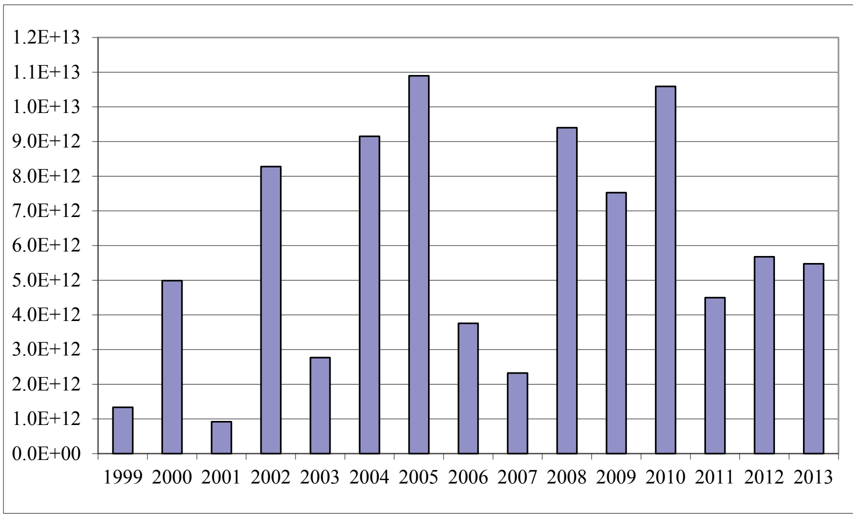


Figure 6.2.2.1.1:Bay of Biscay sardine:.Historical series of sardine egg abundances (number of eggs)

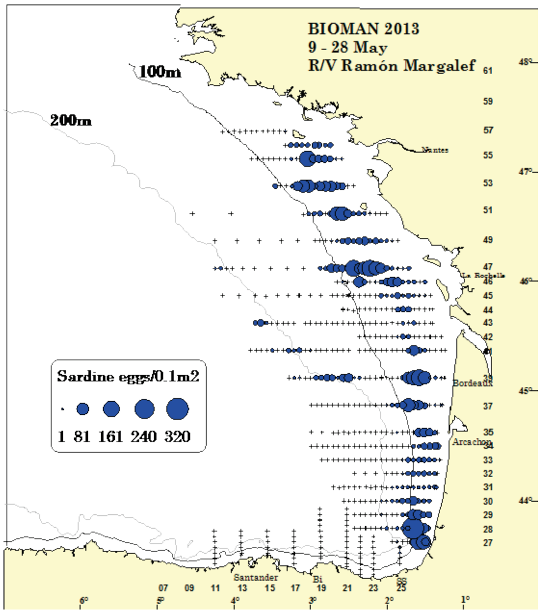
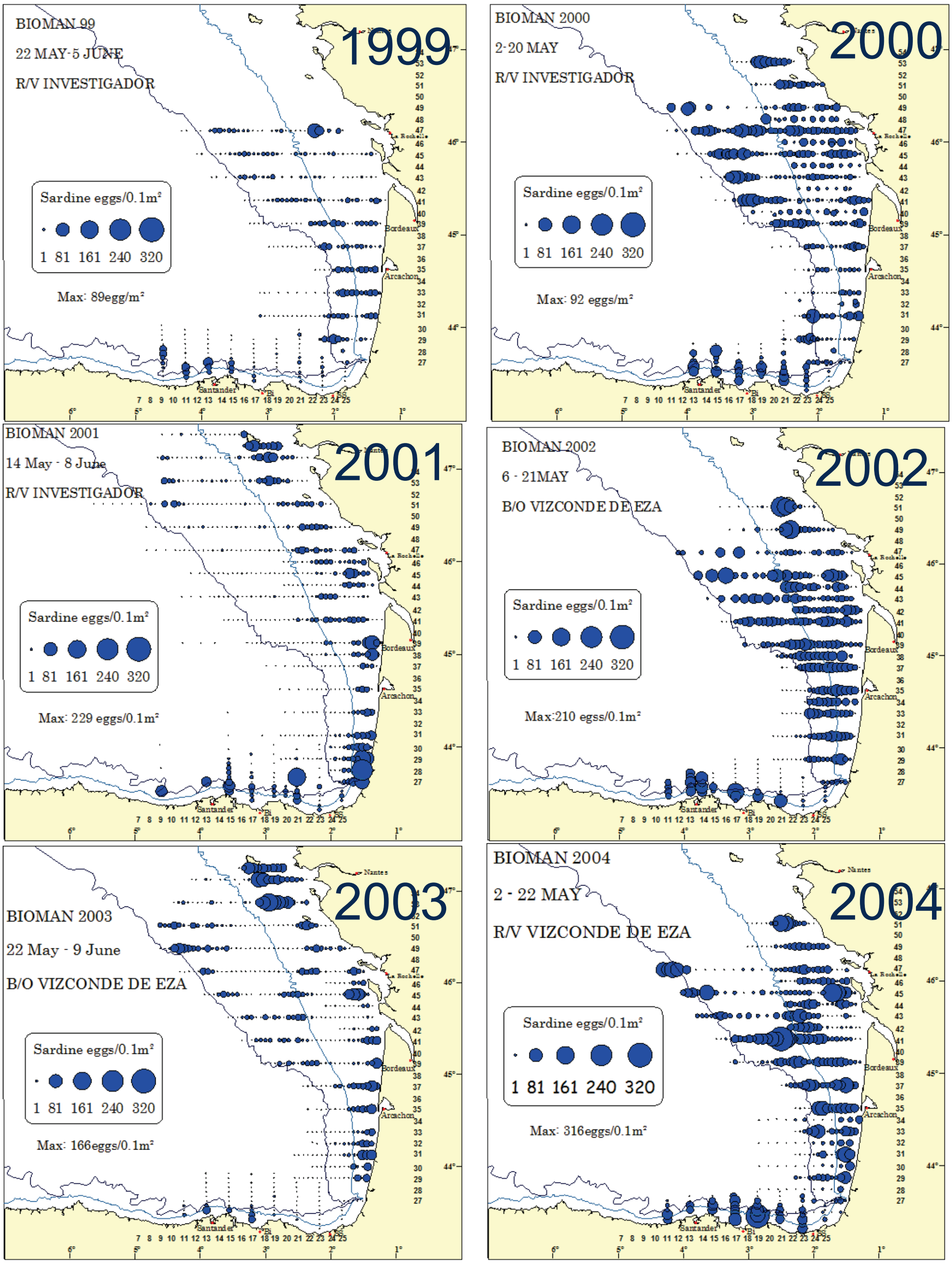
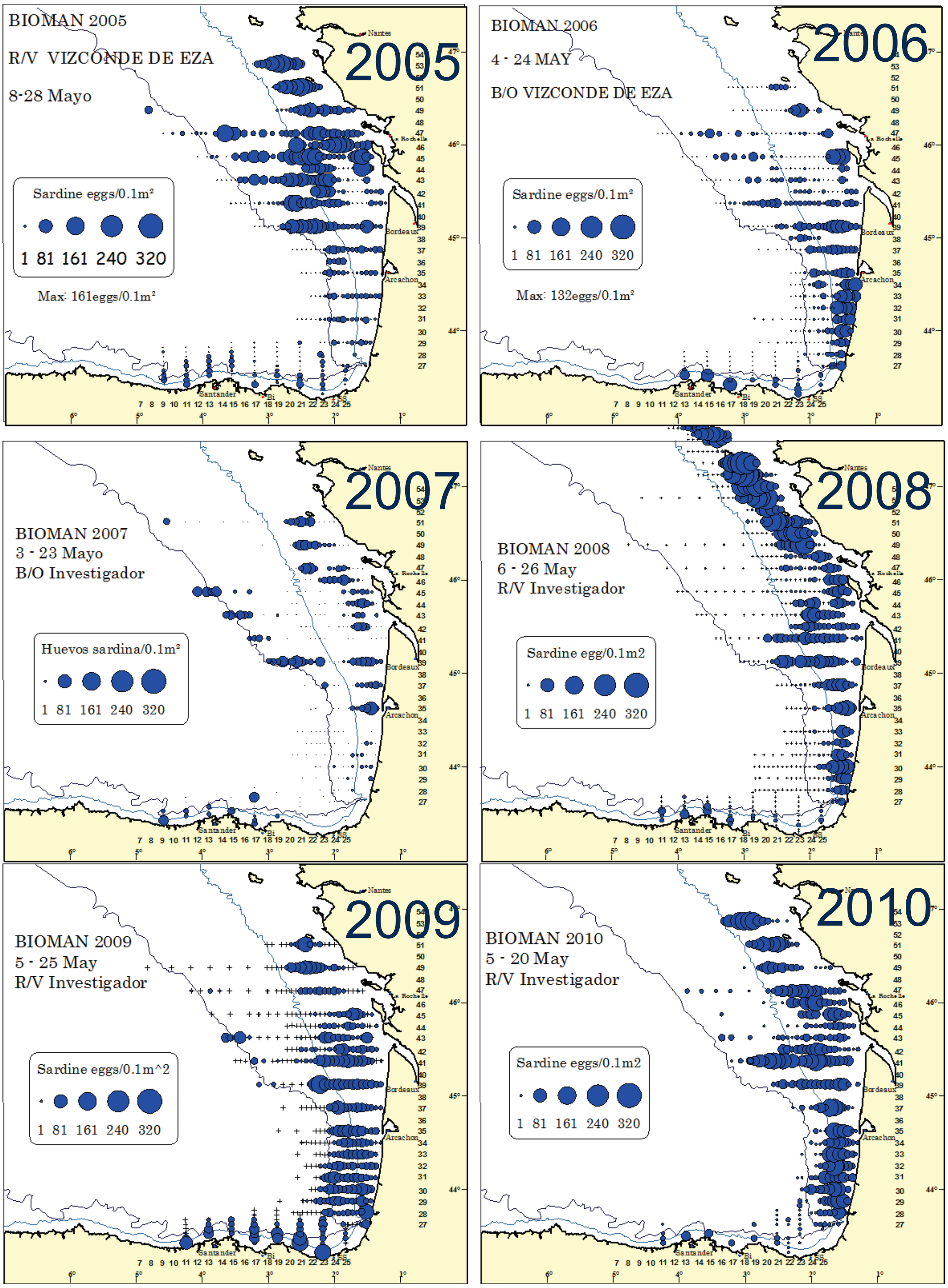


Figure 6.2.2.1.2: Bay of Biscay sardine: Distribution sardine egg abundances (eggs per 0.1m²) from the DEPM survey BIOMAN2013 obtained with PairoVET.


BIOMAN 99
22 MAY-5 JUNE
R/V INVESTIGADOR
1999
Sardine eggs/0.1m²
1 81 161 240 320
Max: 89egg/m²
BIOMAN 2000
2-20 MAY
R/V INVESTIGADOR
2000
Sardine eggs/0.1m²
1 81 161 240 320
Max: 92 eggs/m²
BIOMAN 2001
14 May - 8 June
R/V INVESTIGADOR
2001
Sardine eggs/0.1m²
1 81 161 240 320
Max: 229 eggs/0.1m²
BIOMAN 2002
6 - 21MAY
B/O VIZCONDE DE EZA
2002
Sardine eggs/0.1m²
1 81 161 240 320
Max:210 egss/0.1m²
BIOMAN 2003
22 May - 9 June
B/O VIZCONDE DE EZA
2003
Sardine eggs/0.1m²
1 81 161 240 320
Max: 166eggs/0.1m²
BIOMAN 2004
2 - 22 MAY
R/V VIZCONDE DE EZA
2004
Sardine eggs/0.1m²
1 81 161 240 320
Max: 316eggs/0.1m²


BIOMAN 2005
R/V VIZCONDE DE EZA
8-28 Mayo
2005
Sardine eggs/0.1m²
1 81 161 240 320
Max: 161eggs/0.1m²
BIOMAN 2006
4 - 24 MAY
B/O VIZCONDE DE EZA
2006
Sardine eggs/0.1m²
1 81 161 240 320
Max: 132eggs/0.1m²
BIOMAN 2007
3 - 23 Mayo
B/O Investigador
2007
Huevos sardina/0.1m²
1 81 161 240 320
BIOMAN 2008
6 - 26 May
R/V Investigador
2008
Sardine egg/0.1m2
1 81 161 240 320
BIOMAN 2009
5 - 25 May
R/V Investigador
2009
Sardine eggs/0.1m^2
1 81 161 240 320
BIOMAN 2010
5 - 20 May
R/V Investigador
2010
Sardine eggs/0.1m2
1 81 161 240 320
Nantes
Bordeaux
Arcachon
Santander

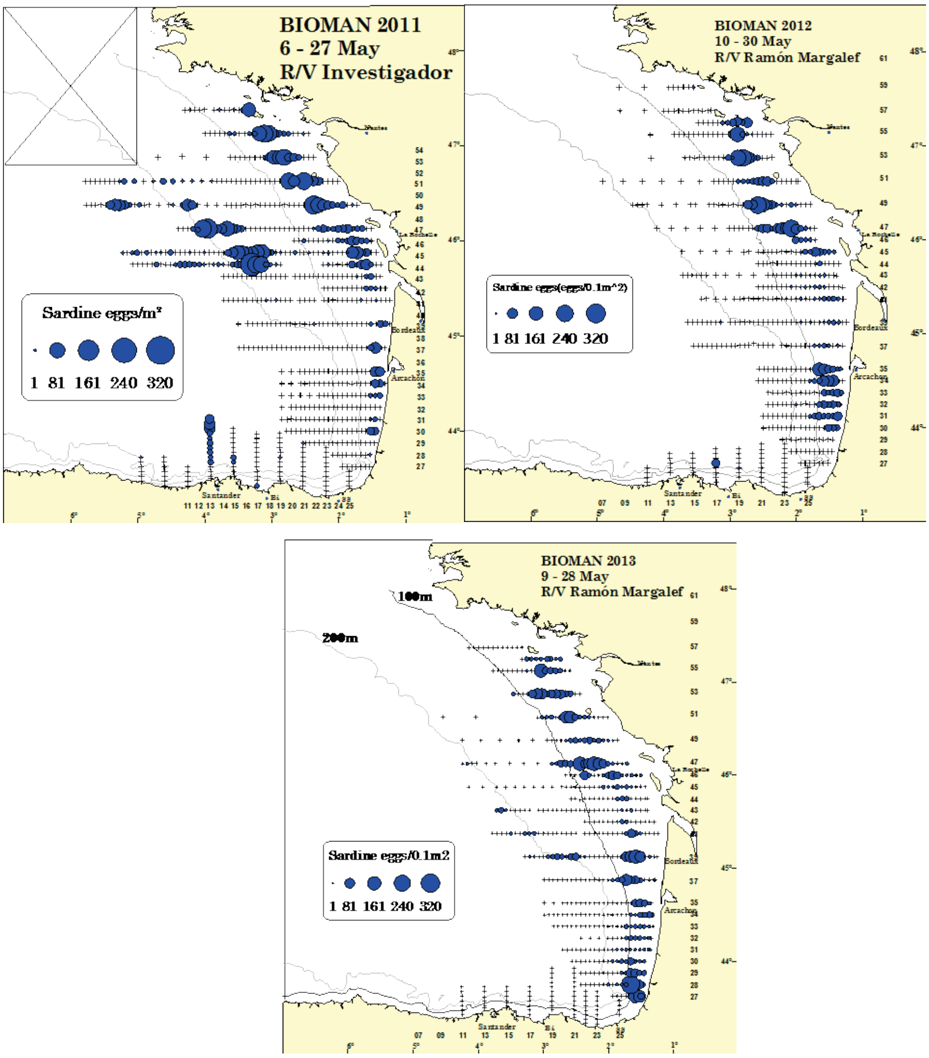


Figure 6.2.2.1.3: Bay of Biscay sardine: Sardine egg distribution and abundance (eggs per 0.1m2) from 1999 to 2013.

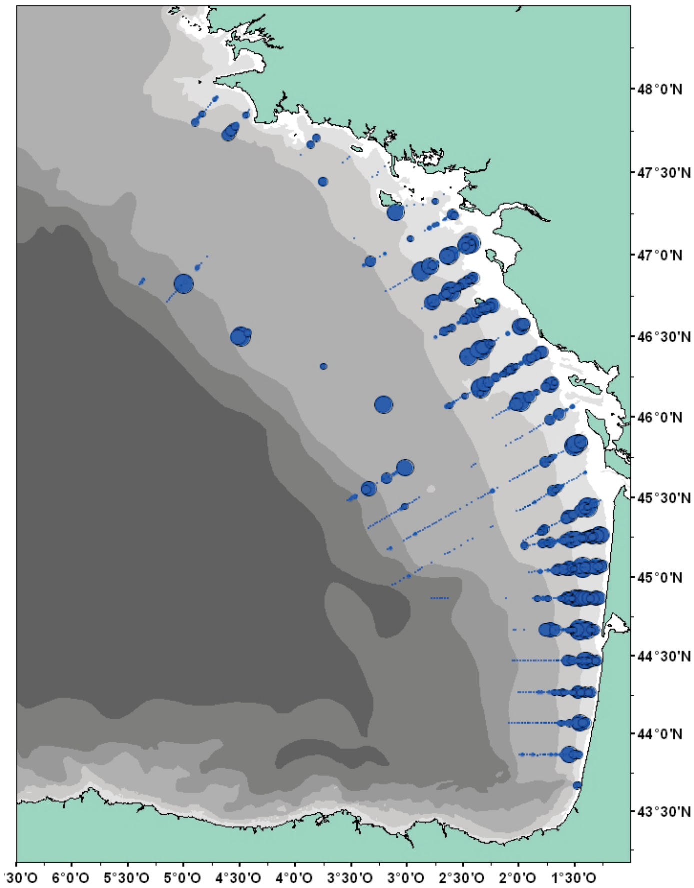


Fig. 6.2.2.2.1 : Adult sardine distribution (density / ESDU) during PELGAS13

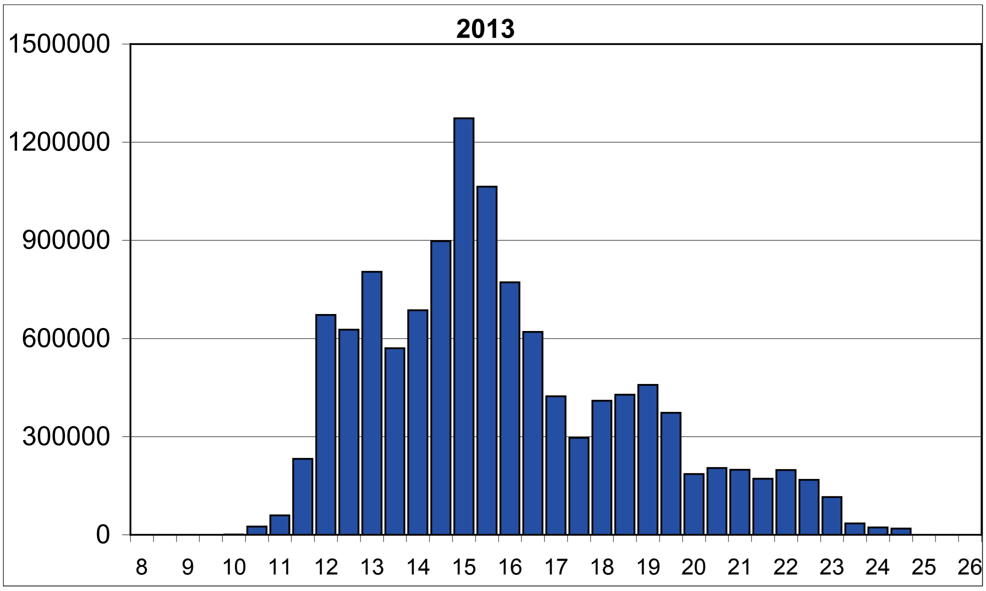


Fig. 6.2.2.2.2 : Sardine length distribution during PELGAS13

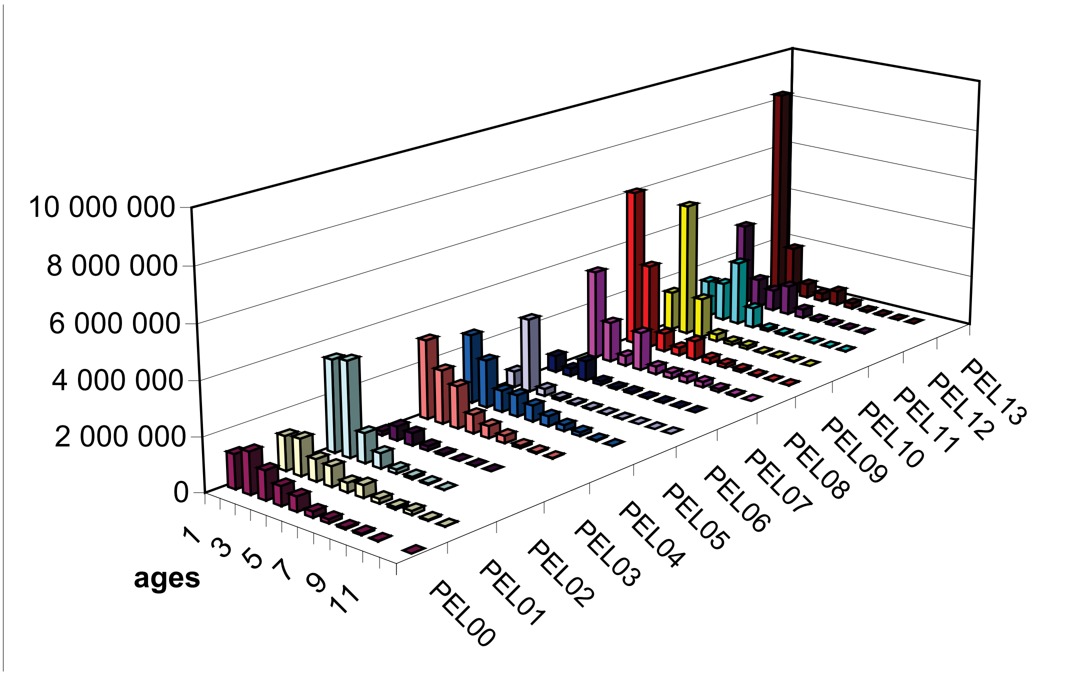


Fig 6.2.2.2.3 : sardine age distribution along the PELGAS surveys

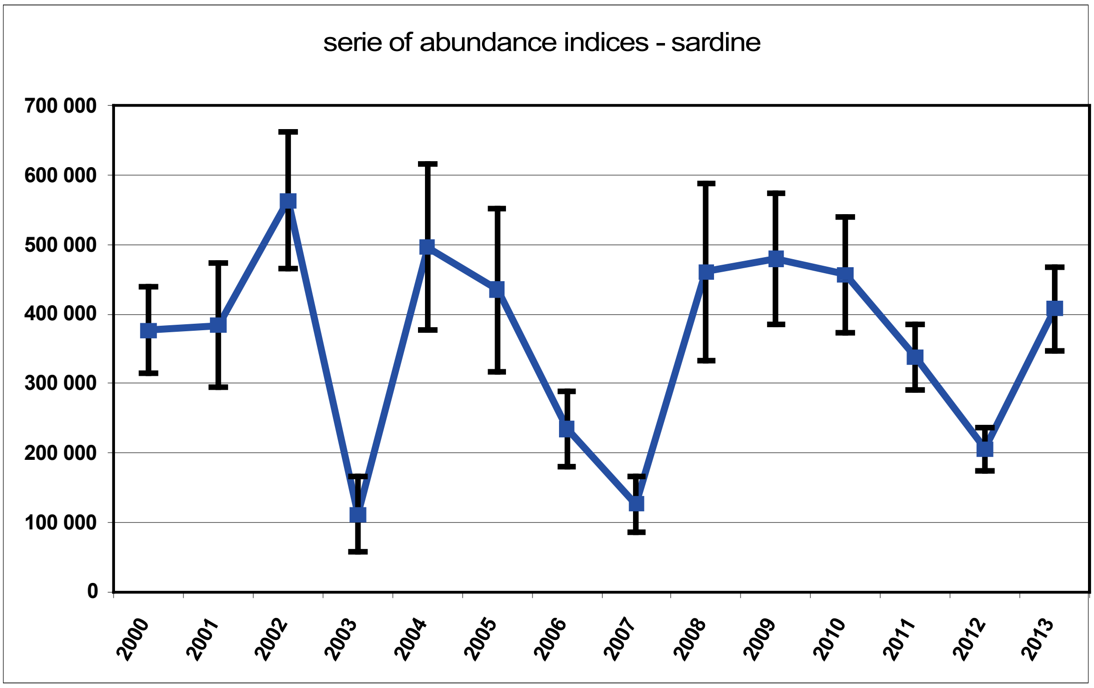


Fig 6.2.2.2.4 : sardine abundance indices along the PELGAS surveys

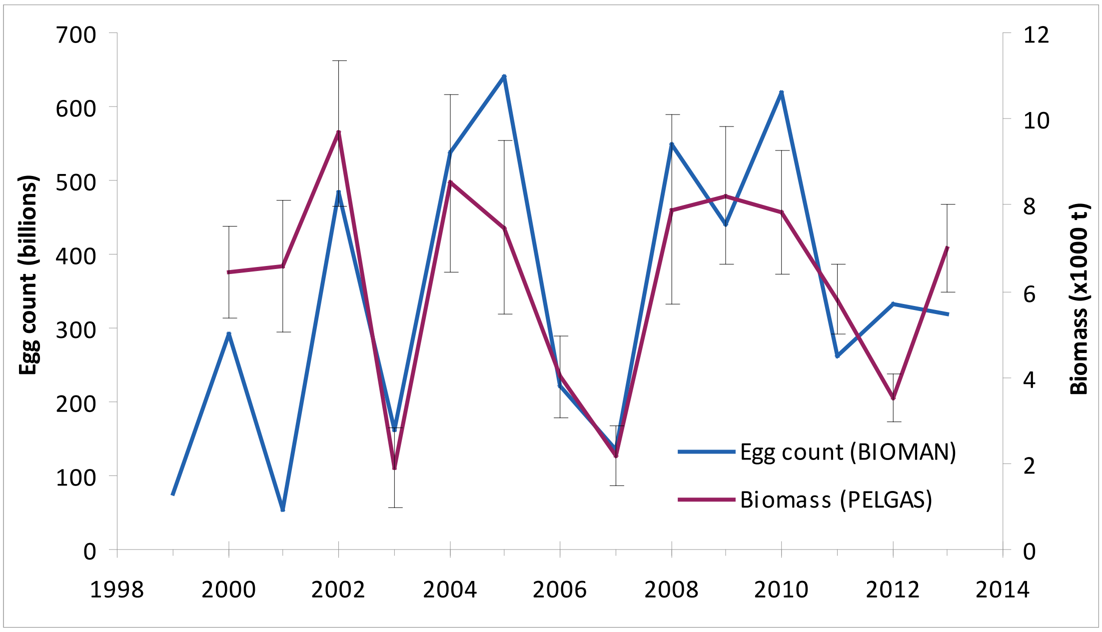


Figure 6.2.4.1.1: Survey indices from Pelgas (acoustic) and Bioman (DEPM) surveys in VIIIa,b,d.

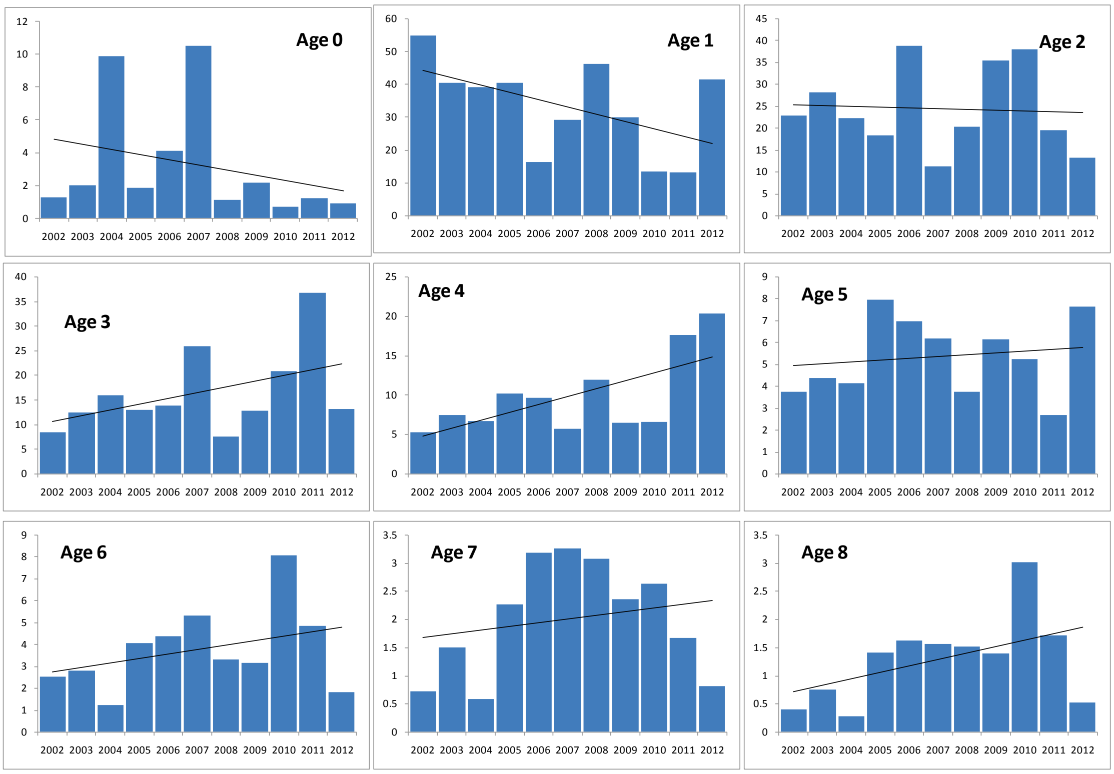


Figure 6.2.4.1.2: Relative composition of catches at age for the commercial fleets in VIIIa,b,d

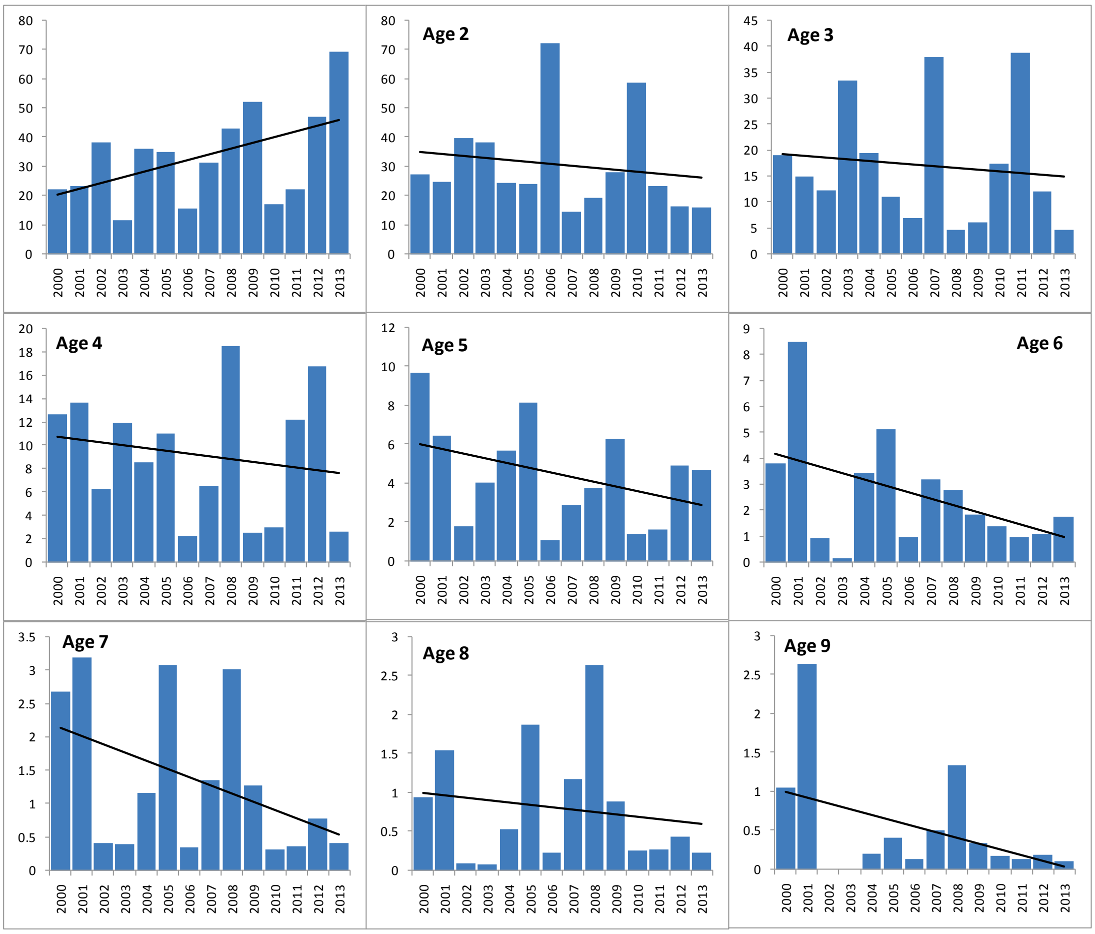


Figure 6.2.4.1.3: Relative composition of the catches at age for PELGAS survey in VIIIa,b,d.

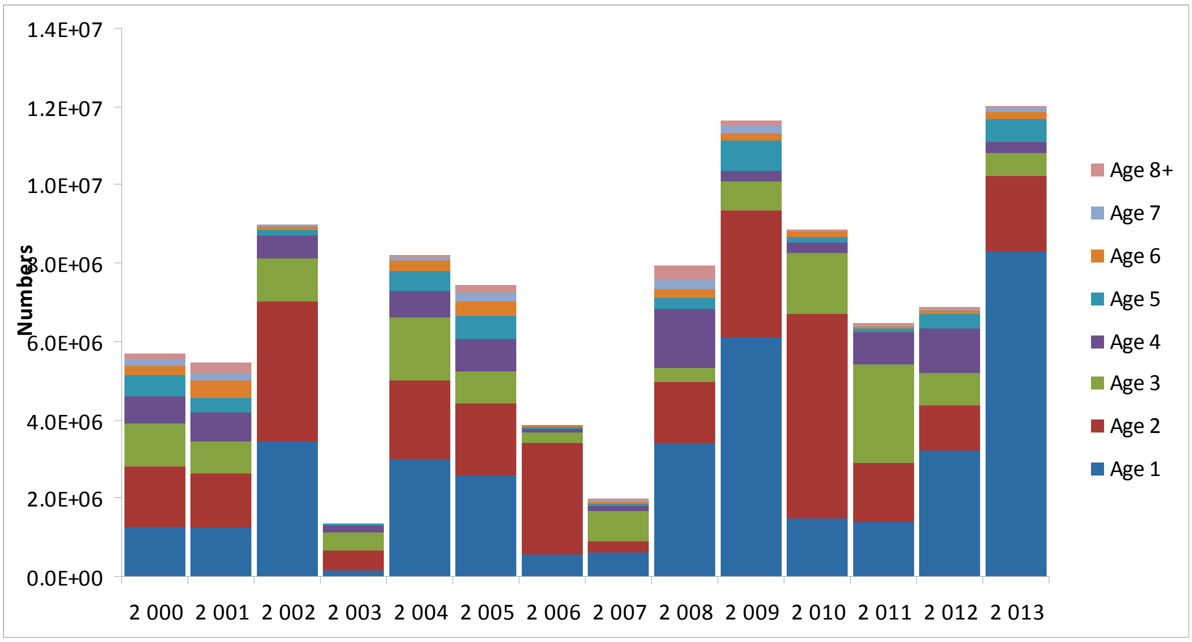


Figure 6.2.4.1.4: Composition of catches at age for the PELGAS survey in VIIIa,b,d.

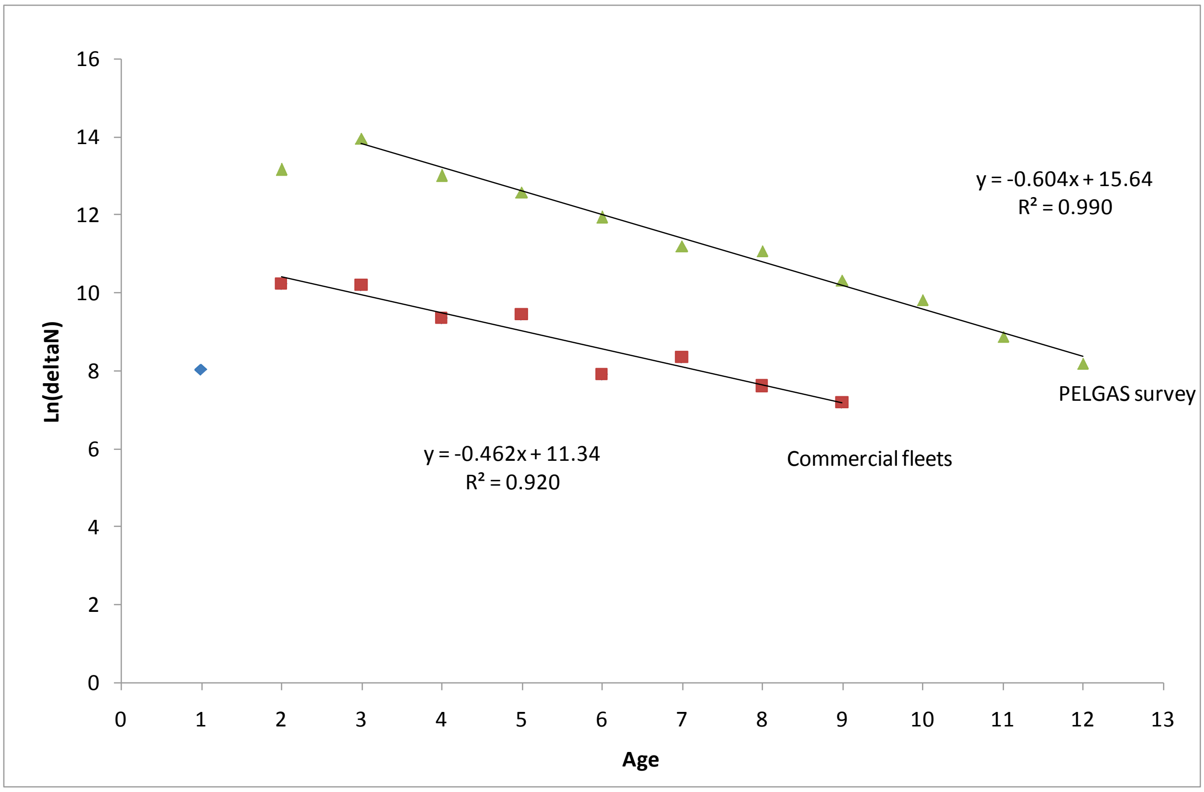


Figure 6.2.4.1.5: Total mortality estimated from both PELGAS and commercial fleets in VIIIa,b,d.

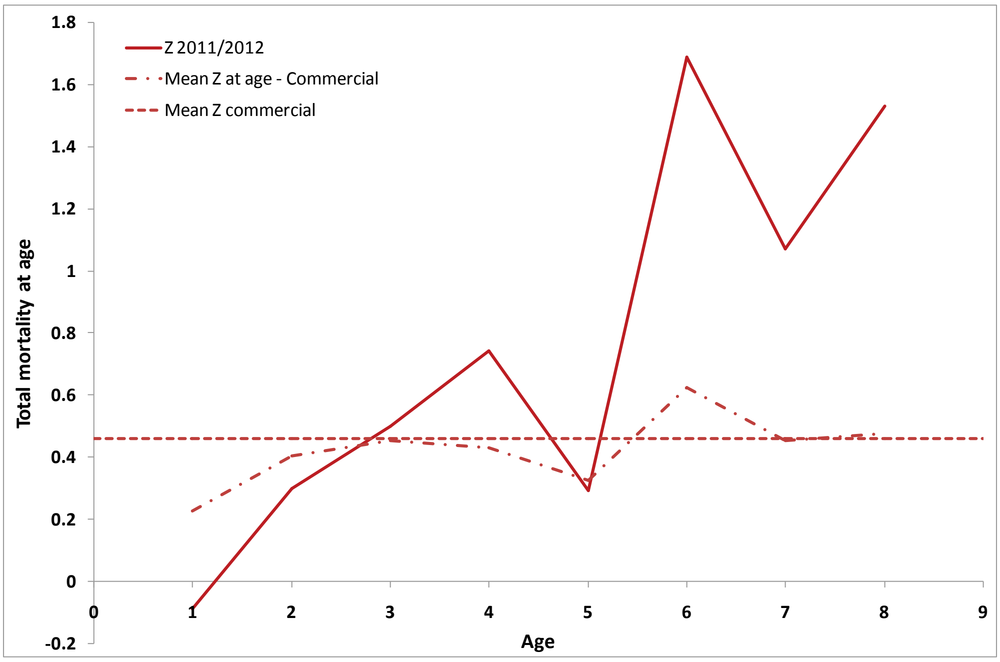


Figure 6.2.4.1.6: Total mortality at age estimated from the commercial fleets in VIIIa,b,d.

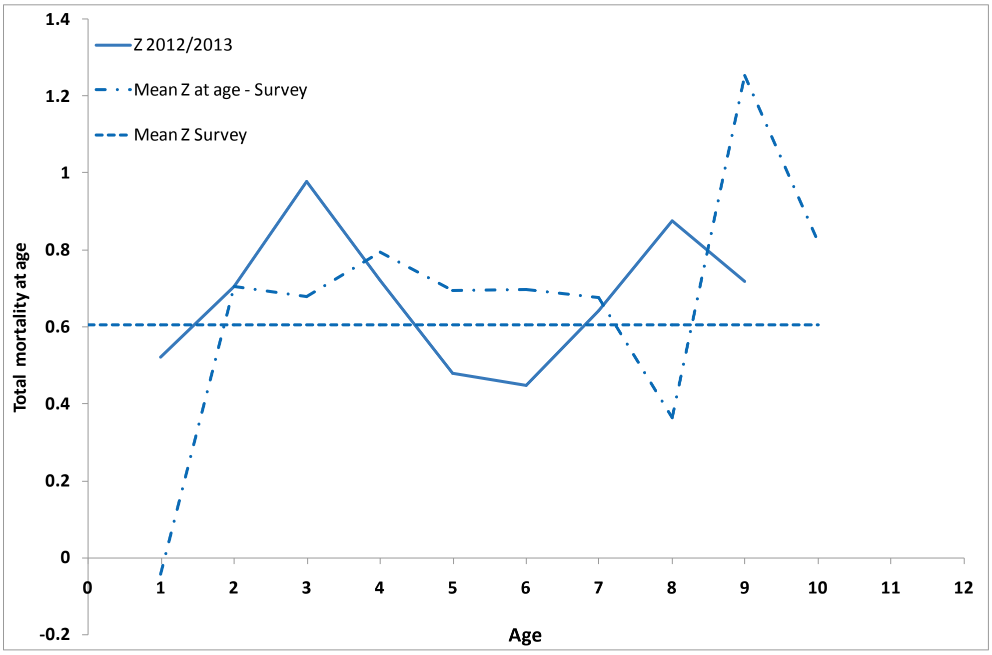


Figure 6.2.4.1.7: Total mortality at age estimated from the PELGAS survey in VIIIa,b,d.

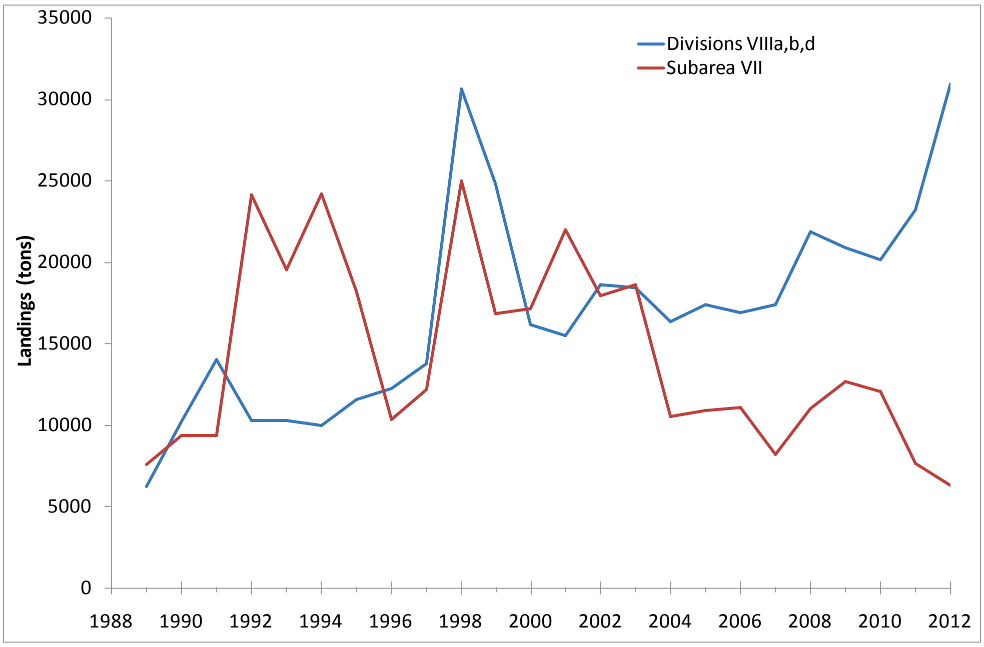


Figure 6.2.4.2.1: Landings in VIIIa,b,d and VII

7 Sardine in VIIIc and IXa

7.1 ACOM Advice Applicable to 2013, STECF advice and Political decisions

ICES advised on the basis of precautionary considerations that landings in 2013 should be no more than 55 000 t.

7.2 The fishery in 2012

7.2.1 Fishing Fleets in 2011

Details about the vessels operated by both Spain and Portugal targeting sardine are given in **Table 7.2.1.1**.

Sardine is taken in purse seine fisheries throughout the stock area.

In northern Spain, data from 2012 indicates that the number of purse seiners were 165, with mean vessel length and power of 18m and 233 HP, respectively. In the Gulf of Cadiz, purse seiners taking sardine are generally targeting anchovy (n = 76) and range in size from 11 to 24 m with a mean vessel length of 17 m (horse power between 28 and 510 with a mean of 181).

In Portuguese waters, fleet data (INE, 2012) indicate that, in 2012, 146 vessels were licensed for purse seining, with mean vessel length of 38 GT and engine power category of 200 Kw.

7.2.2 Catches by fleet and area

The WG estimates of landings and catches are shown in **Tables 7.2.2.1**. and **7.2.2.2**.

As estimated by the Working Group, sardine landings in 2012 catches have suffered a sharp decline in comparison with those of 2011 (Tables 7.2.2.1 and 7.2.2.2, **Figure 7.2.2.1**). Total 2012 landings in divisions VIIIc and IXa were 54 857 t, i.e. a decrease of 31.8% with respect to the 2011 values (80 403). The bulk of the landings (99%) were made by purse-seiners. In Spain, landings of sardine, 23 275 tonnes, have remained constant in relation to values from 2011 (23 180 tonnes). Both ICES subdivisions IXaS-Cadiz and IXaN showed a substantial decrease in catches (33.2% in subdivision IXaS-Cadiz and 26.1% in IXaN) while subdivision VIIIc showed a 53.4% increase. In Portugal, landings in 2012 (31 583 tonnes) were 44.8% lower than the landings in 2011 (57 223 tonnes, see also Section 7.8). This decrease in landings originated in all subdivisions and specially in the IXaS subdivision (54.7% decrease in catches in IXaS-Algarve, 33.9 % decrease in IXaCS and a 47.1% decrease in IXaCN).

Table 7.2.2.1 summarises the quarterly landings and their relative distribution by ICES Subdivision. Fifty-nine percent of the catches were landed in the second semester and 36% of the landings took place off the northern Portuguese coast (IXaCN), showing a smaller contribution than in previous years (i.e. last year the contribution of IXaCN was a 46% of the total catches in the stock). The percentage of catches in the northern areas (IXa and VIIIc) has increased from last year, despite de 26% decrease in catches in the IXaN subdivision, due to the Cantabrian Sea (VIIIc) rise, that has doubled its contribution over last year (24% in 2012 *vs* 11% in 2011).

The southern areas (IXaS Algarve and IXaS Cadiz) account for 16% of the total values in 2012, moderately below the value in 2011 (19%).

7.2.3 Effort and catch per unit effort

No new information on fishing effort has been presented to the WG.

7.2.4 Catches by length and catches at age

Tables 7.2.4.1a,b,c,d show the quarterly length distributions of landings from each subdivision. Annual length distributions (Table 7.2.4.1.) were bimodal in Spain in subdivisions IXaNorth with modes at 17 and 20.5 cm. Sardine in subdivisions VIIIcE, VIIIcW and IXaS-Cádiz showed single modes at 21, 22 and 20.5 cm respectively. For Portugal sardine in IXaCN, IXaCS showed bimodal length distributions (at 12 and 19.5 cm and at 21 cm and 16 cm respectively) whilst the IXaS length distribution did not showed a clear mode.

Table 7.2.4.2 shows the catch-at-age in numbers for each quarter and subdivision. In **Table 7.2.4.3**, the relative contribution of each age group in each Subdivision is shown as well as their relative contribution to the catches. Age 1 fish was dominant in IXaN and IXaCN. The cohort of 2007 (which was strong in French waters) has a great contribution in the VIIIcE subdividision (20%), but the mayority of catches were age 4 (35%) in this subdivision. No clear pattern of ages was observed in IXaCS and IXaS-Algarve. Ages 0 and 1 (with a total contribution of the 84%) dominate in IXaS-Cádiz. The Historical catches at age are shown in **Table 7.2.4.4.**

7.2.5 Mean length and mean weight at age in the catch

Mean length and mean weight at age by quarter and Subdivision are shown in **Tables 7.2.5.1** and **7.2.5.2.**

7.3 Fishery independent information

Figures 7.3.1 and 7.3.2. show the time series of fishery independent information for the sardine stock.

7.3.1 Iberian DEPM survey (PT-DEPM-PIL+SAREVA)

As part of the Iberian DEPM survey, surveys are carried out every three years by Portugal (IPIMAR) and Spain (IEO). In 2011, the Portuguese survey took place in February-March covering the western and southern distribution area of the stock, and the Spanish survey took place in March-April covering the northern area. As described in the Stock Annex, the total spawning biomass from the two surveys is used in the assessment.

The DEPM survey is planned and discussed within WGACEGG (e.g WGACEGG, 2012). As happened in past years, the results presented to this WG (WD2012, Angélico *et al.*) have been fully discussed by WGACEGG and the 2011 DEPM values, that were considered provisional in WGHANSA2012, were revised. The final B_{1+} value for 2011 DEPM is 485 thousand tonnes instead of the B_{1+} = 463 thousand tonnes provisionally reported. The updated value was adopted for the assessment.

Minor changes of values from 2008 backwards of the order of 10% (discussed in the WGACCEGG, 2012) have not been taking into account in the 2013 assessment. The WG considers that such modifications should be considered in the next benchmark.

7.3.2 Iberian acoustic survey (PELACUS04+PELAGO)

As part of the Iberian acoustic survey, surveys are carried out each year by Portugal and Spain to estimate small pelagic fish abundance in IXa and VIIIc. The Iberian acoustic survey is planned and discussed within WGACEGG (e.g WGACEGG, 2011). As described in the Stock Annex, the total numbers-at-age from the two surveys are used as input to the assessment.

There are two annual surveys carried out to estimate small pelagic fish abundance in IXa and VIIIc using acoustic methods. The April-May 2013 Portuguese survey (PELAGOS13) took place onboard the RV "Noruega" while the Spanish survey (PELACUS0413) took place in March-April onboard the RV "Miguel Oliver".

Both surveys were conducted following the methodology applied in previous years and agreed and revised at the WGACEGG.

7.3.2.1 Portuguese spring acoustic survey

PELAGOS13 survey took place from the 15th April to the 15th May and covered the Portuguese and Gulf of Cádiz waters ranging from 20 to 200 m depth. Detailed objectives, methodology and sampling strategy are described in the WD-Marques et al. (2013) presented in this group. A total of 26 fishing stations were carried out. The most abundant species fished were chub mackerel (Scombrus colias), horse mackerel (Trachurus trachurus) and bogue (Boops boops). Sardine was usually caught together with these pelagic species. Off the south coast, mediterranean horse mackerel (Trachurus mediterraneus) and blue jack mackerel (Trachurus picturatus) were also found. Anchovy was mainly found off Cadiz and eastern Algarve coast with a small patch found off the northwest coast. Sardine was distributed all over the coast, but in small quantities. Most of the sardine was distributed in a small area south of Peniche (**Figure 7.3.2.1.1**). Total estimated sardine biomass in the Portuguese coast and Gulf of Cadiz was 112 thousand tonnes corresponding to 4471 million individuals (**Table 7.3.2.1.1**). The biomass is similar to that in 2011 (12% lower) whereas the number of fish increase 37% (**Figures 7.3.1**. and **7.3.2**) and are at the low level of historical series. Age 1 fish were predominant in all areas (except Algarve) but their overall abundance was low (1/10th the abundance of the 2004 strong cohort at the same age) indicating a low 2012 recruitment .

Data on sardine egg distribution (presence/absence) off the northwest area (analysis of samples not yet completed) derived from the CUFES sampling during this survey is shown in **Figure 7.3.2.1.2**. For this are the egg distribution matched the sardine acoustic energy mapping that highlighted a very coastal distribution in particular north of Cape Carvoeiro. The higher egg abundances also coincided with the major schools found southe of Peniche, a region were spawning is recurrent. In the area already analysed the average egg abundances in 2013 were very similar to the ones observed during the last survey in 2011. The number of stations with eggs in 2013 was considerably higher (60%) than in 2011 (27%). In fact, 2013 presented one of the largest spawning areas of the survey series for this region. However this may have resulted of egg advection due to the oceanographic conditions prevalent during this year´s survey (WD-Marques et al. 2013).

During the mackerel horse mackerel egg survey carried out earlier this year, in mid February the sardine egg abundances estimated from CalVET sampling showed a patchy pattern with the southern region with more continuous distribution than over the northern shelf. Average egg density was slightly lower than during the 2011 sardine DEPM survey. The water temperature (not shown), in particular in the NW region, in Februray this year was lower than in previous winters.

The 2013 survey age composition data is consistent with the year-class signal from previous surveys (**Figures 7.3.2.1.3** and **7.3.2.1.4**).

7.3.2.2 Spanish spring acoustic survey

The Spanish survey took place for first time onboard the RV "Miguel Oliver" from the 6th March to 9th April. The area covered extended from the Galician-Portugal border to southern French waters and from 30 to 1000 m depth. Detailed objectives, methodology and sampling strategy are described in the WD-Riveiro et al. (2013) presented in this group.

PELACUS 0313 was characterised by:

1) **The change of the R/V Thalassa by the R/V Miguel Oliver.** This year, no intercalibration was made (it would be done next year). Vessel effect on acoustic assessment is very difficult to achieve when both vessels have similar characteristics (i.e. low noise radiated level). We believe vessel effect on the total acoustic energy –NASC– recorded would be negligible since no differences in fish behaviour should be expected due to the similar vessel characteristics. Another source of random error is the fishing stations which could change the species composition and/or proportion of the pelagic community. Again, the pelagic trawl with a vertical opening of about 16-18 m (20-25 in horizontal one) would have had the same performance as the Thalassa one. We had not seen any particular escaping behaviour in front of the gear and we assumed the fishing stations were ground-truthing. There was no intercalibration between R/V Miguel Oliver and R/V Noruega either. Therefore, previous uncertainty related to the combination of the two surveys still persists.
2) **Bad weather conditions and very coastal distribution of fish schools.** The survey was characterised by a very bad weather conditions during the first two weeks which did not allow working properly. Moreover, the weather conditions during the rest of survey were almost similar. As a consequence, most of the coastal pelagic fish community remained very close to the coast. This schools were inaccessible to the fishing gear and it was not possible to allocate directly into fish species on account their morphological, acoustic and geographical characteristics (33% of the total acoustic energy –NASC- was unable to be properly allocated into fish species).

On account this last feature, we were only able to properly assess the outer part of the sardine distribution (i.e. between 90 m and the shelf-break), and therefore a very low biomass was estimated, (3343 metric tonnes).

Outside the coastal area (>90 m depth) sardine distribution was scarce, and occurred in small schools (probably as a consequence of the bad weather conditions and low population abundance). It was only found in a small area in VIIIc-West and in the eastern part of the VIIIc-East. The total biomass estimated in this area was 2.530 tonnes corresponding to 38,4 million fish.

Together with this assessment, made on account the fish proportion found at the ground truth fishing station, a direct assignation was achieved by echogram scrutinization. Although the experience, only few schools could be properly allocated to sardine, all of them located inside the Rias Baixas, giving an estimation of 813 tonnes (16 million fish). Overall, total biomass estimation is 3.343 tonnes, corresponding to 54 million fish (**Figure 7.3.2.2.1** and **Table 7.3.2.2.1**).

Sardine ranged in length from 14 to 24.5 cm, with a mode at 21.5 cm (**Figure 7.3.2.2.2**) which corresponds to quite large fish. Most fish (24% of the abundance and 19% of the biomass) in the entire surveyed area were assigned as belonging to the age class 5.

By sub-area, in subdivision IXaN (South of Galicia) the population was dominated by age 1 fish whilst in the eastern part of the Cantabrian area the population was mainly composed by older individuals (age 5).

On the contrary, the total number of sardine eggs found at the CUFES stations showed an increase compared to those found in 2012 (from 1665 to 5936). Nevertheless, the distribution area was rather similar, with a significant gap between the southern area (IXaN) and the inner part of the Bay of Biscay (VIIIc-East-east) (**Figure 7.3.2.2.3**).

Given the amount of unallocated schools in shallower waters, the acoustic sardine assessment is considered uncertain since only the outer part of the distribution (waters deeper than 90 m) was properly surveyed. The egg distribution, similar to that found the last year could indicate that the stock level might be similar. The higher abundance of eggs could indicate an increase in the sardine abundance. But other explanations are possible: the significant increase in egg number could be related with the shift in the survey time (two weeks earlier than the previous year), thus closer to the peak spawning.

In order to try to quantify the amount of sardine biomass not assessed during the PELACUS survey (as a consequence of the 33% of the energy not allocated), we did a sensitivity exercise assuming the sardine biomass in the coastal zone represents between 40%-70% of the total energy (percent observed between 1992-2002 in coastal waters). If we assume that such proportion of backscattering energy for sardine in coastal waters is stable and independent of the total energy then the biomass estimation could include an estimated proportion of the unallocated backscattering energy in coastal waters ranging between 30% to 60 %. This will increase the estimation in around 7 to 13 thousand tonnes (10-16 thousand tonnes in total), which is more consistent with recent estimates.

In spite the lack of fishing stations in coastal waters allowing distributing the backscattering energy into fish species, we can conclude that the sardine biomass would remain in the lowest level of the time series, with no signal of recovery, nor of a good incoming year class in the surveyed area (IXa-North and VIIIc).

The historical coherence of the numbers at age estimated in this acoustic Spanish survey can be checked in Figures 7.3.2.2.4.

7.4 Biological data

7.4.1 Mean weight at age in the stock and in the catch

Mean weight at age in the catch are shown in **Table 7.4.1a**.

According to the stock annex (WKPELA 2012), the mean weight at age in the stock is obtained from samples collected in the acoustic surveys. In 2012 the Portuguese acoustic survey was not carried out. Therefore, the 2012 weight at age was assumed to be equal to the 2011 weight at age (**Table 7.4.1b**).

7.4.2 Maturity at age

Following the Stock Annex (WKPELA 2012), in years with no DEPM survey, maturity at age is assumed to be 0.8 for age 1 and 1 for ages 2+.

7.4.3 Natural mortality

Following the Stock Annex (WKPELA 2012), natural mortality is:

	M, year^{-1}
Age 0	0.8
Age 1	0.5
Age 2	0.4
Age 3	0.3
Age 4	0.3
Age 5	0.3
Age 6	0.3
Mean (2-5)	0.3

7.4.4 Catch-at-age and abundance-at-age in the spring acoustic survey

The historical series of catches-at-age and abundance-at-age in the spring acoustic survey are presented in Figures 7.4.4.1 and 7.4.4.2.

7.5 Assessment Data of the state of the stock

7.5.1 Stock assessment

The assessment follows the Stock Annex (WKPELA 2012) and is a SPALY. As mentioned in the Stock Annex, the model requires input fishery data for the interim year since a survey is input for that year (2013). Given these data are not included in the model fit and thus do not affect the assessment we simplified the way to derive the catch-at-age values: instead of doing a projection assuming an arbitrary recruitment for the interim year of 4000000 individuals, as indicated in the stock annex, we used catch-at-age values derived from the short term projection in WGHANSA2012.

The table below presents an overview of the model settings. Additional details can be found in the Stock Annex.

Model structure and assumptions:	
M	M-at-age 0=0.8, M-at-age 1=0.5, M-at-age 2=0.4, M-at-age 3+=0.3, all years
Recruitment	No SR model; annual recruitments are parameters, defined as lognormal deviations from a constant mean value penalized by a sigma of 0.55 (the standard deviation of log(recruits) estimated in WGANSA 2011)
Catch biomass	Assumed to be accurate and precise. The F values are tuned to match this catch. Total catch biomas by year is assumed to be a median unbiased index of abundance.
Fishing mortality	Fishing mortality is applied as the hybrid method. This method does a Pope's approximation to provide initial values for iterative adjustment of the continuous F values to closely approximate the observed catch.
Initial population	N-at-age in the first year are parameters, derived from an input initial equilibrium catch, the geometric mean recruitment and the selectivity in the first year.
Fishery selectivity-at-age	S-at age are parameters, each estimated as a random walk from the previous age; S-at-age 0 not estimated, used as the reference; S-at-ages 4 and 5 assumed to be equal to S-at-age 3.
Fishery selectivity over time	Two periods: 1978-1990 with selectivity-at-age varying as a random walk and 1991-2010 for which selectivity-at-age is fixed over time
Survey selectivity-at-age	S-at age are parameters, each estimated as a random walk from the previous age; S-at-age 1 not estimated, used as the reference; S-at-ages 3 to 5 assumed to be equal to S-at-age 2; fixed over time
Fishery catchability	Scaling factor, median unbiased
Acoustic survey catchability	Scaling factor, mean unbiased
DEPM catchability	Scaling factor, mean unbiased
Precision of acoustic data	A standard error of 0.25 assumed for all years for the acoustic index (total number of fish). A sample size=50 is assumed for all years of the acoustic age composition.
Precision of DEPM data	A standard error of 0.25 assumed for all years for the DEPM index (spawning biomass).
Precision of catch-at-age data	Ageing imprecision is 0.1 at Age0, 0.2 at Age1, 0.3 at Ages 2-5, 0.4 at age 6+ .The sample size for annual age compositions is 50 in 1978-1990 and 75 in 1991-2012
Objective function	Log likelihood function, user-weighted composite of components from the different data sources. Variance estimates for all estimated parameters are calculated from the Hessian matrix.

Table 7.5.1.1 shows the parameters estimated by the assessment model. Estimates of fishing mortality at age and numbers at age are presented in **Tables 7.5.1.2 and 7.5.1.3**. **Figures 7.5.1.1** and **7.5.1.2** show the fit of the model to the acoustic and DEPM survey indices (total number of fish and spawning biomass by year, respectively). As noted in last years assessment, the model fits poorly to some acoustic and DEPM surveys. The two most recent acoustic surveys, 2011 and 2013 are well below the model estimates whereas the two most recent DEPM surveys, 2008 and 2011 are well above the model estimates.

Figure 7.5.1.3 shows the model residuals from the fit to the catch-at-age composition (a) and the acoustic survey age composition (b). The residuals from the present assessment are comparable to those from last years' assessment. Catch residuals show some clustering being generally larger at age 0. Acoustic survey residuals shift from mostly positive to mostly negative around 2000, reflecting some conflict between the DEPM and acoustic signals.

The survey selectivity pattern is comparable to that obtained in last years' assessment (**Figure 7.5.1.4**). The same applies to the fishery selectivity pattern except from the 6+ group: for this age group, the present assessment estimates a larger selectivity in the earlier assessment period (1978-1990), when selectivity is allowed to vary over time.

The assessment estimates of B1+, recruitment and fishing mortality are presented in **Table 7.5.1.4** and **Figure 7.5.1.5**). The model estimates standard errors of SSB, recruitment and ApicalF (maximum F over age within years). We assume the CVs of SSB and ApicalF apply to B1+ and F(2-5). B1+ in 2012=185 thousand t (CV=23%) is 64% below the historical mean 1978 – 2011. B1+ shows an decrease of 18% from 2011 to 2012. F in 2012 is estimated to be 0.34 $year^{-1}$(CV=26%), 3% above the historical mean. F decreased 33% from 2011 to 2012.

As noted in last years' assessment, the series of historical recruitments 1978 – 2012 shows a significant linear downward trend (r^2=0.37, p<0.001, n=34). Contrary to the perception in last years' assessment, the 2011 recruitment is estimated to be low (4361 millions).

The R2012 estimate, 5769 millions (CV=24%), is 27% lower than the historical geometric mean. This estimate is at the level of the geometric mean of the recent low recruitments 2008-2012. The estimate of the recruitment in the last year of the assessment (2012 in the present assessment) is supported by the 2013 Iberian acoustic survey index.

7.5.2 Sensitivity of the assessment to the use of the 2013 survey

Considering the problems outlined in section 7.3.2.2, we carried out a sensitivity test to evaluate the effect on the assessment of assuming a larger uncertainty in the 2013 acoustic survey compared to earlier surveys and the possibility that it has underestimated sardine abundance. Three runs were carried out: Run 1, without the 2013 acoustic survey, Run 2 assuming a 50% CV in the survey and Run 3 assuming that the biomass in the PELACUS survey is 15 thousand t (i.e. approximately 5 times the estimated biomass, see section 7.3.2.2 for the basis of this assumption). The survey age composition for Run 3 was obtained raising the estimated survey numbers to the assumed biomass. The remaining data and options were the same as in the SPALY assessment (Section 7.5.1).

A comparison of these runs with the SPALY2013 assessment and last year's assessment are shown in **Figure 7.5.2**. Two distint groups are apparent, one group including Run 1, Run 2 (no survey and 50% CV) and the WGHANSA2012 assessment and the other group including Run 3 (inflated biomass in Spanish survey) and the SPALY2013. The biomass estimates from Runs 1 and 2 differ 25% in 2012 and 12% in 2011. Both are close to the WGHANSA2012 assessment. The differences to the SPALY 2013 are major both in recent years and in the earlier assessment period, with biomass estimates being 28-50% lower in the SPALY2013 in the last two years.

Finally, the assumption that the 2013 Spanish survey has underestimated the sardine abundance by ~1/5 has a negligible effect on the assessment. This is due to the fact that the Portuguese survey is, in the last years, the major contribute to the total survey index and therefore even a large bias in the Spanish survey has a negligible influence on the assessment.

The WG acknowledged the sensitivity of the assessment to uncertainty in the 2013 survey but decided to use this survey in the assessment as indicated in the Stock Annex (SPALY 2013).

7.5.3 Reliability of the assessment

The results from this year's assessment show differences from last year's assessment. These differences are substantial in the recent years (**Figure 7.5.3.1**).

Compared to last year's assessment, B1+ in 2011 is revised downwards 33%, F2011 is revised upwards 65% and R2011 is revised downards 60%. These differences are related to the influence of the low 2013 acoustic survey in the assessment which strengthtened the downward effect of the 2011 acoustic survey already noticed in last year's assessment.

As already noticeable in past assessments (e.g. WGANSA 2011), there is a marked retrospective pattern (2008 – 2011) in the assessment consisting of a gradual reduction of the SSB estimates and an upward shift in F with some influence backwards in time (reaching up to 2002, Figure 7.5.3.1). This retrospective pattern may be caused by conflicting signals in the DEPM and acoustic signals. The DEPM and the acoustic survey showed discrepant trends regarding stock abundance from 2005 to 2008 and then to 2011 (as noted in WGANSA 2011 and WGHANSA 2012). In 2008, the DEPM estimate indicated a much higher stock than the acoustic survey and shifted the assessment upwards. The assessment tends to accommodate the signals from the two surveys by providing broadly an average perspective, as shown by the model fit to each survey (Figures 7.5.1.1 and 7.5.1.2) and by the comparison of biomass estimates (**Figure 7.5.3.2**). As the influence of the 2008 survey on the assessment weakened, the assessment became increasingly influenced by the acoustic survey which, particularly in 2011 an 2013 (an acoustic index was not available for 2012 because the Portuguese survey was not carried out), indicates a sharp abundance decrease.

There may be other causes for the observed retrospective pattern. For example, the assumption that fishery selectivity is fixed over time, as in the present assessment, in a situation that the real selectivity is increasing over time may cause the type of retrospective pattern seen here (e.g. Cadigan and Farrel, 2005; Willberg et al. 2010). Changes in the fishery selectivity with fish abundance are not unlikely in schoaling species like sardine. The actual causes of the retrospective pattern are however, unclear.

As highlighted last year, the 2011 acoustic survey may have provided an underestimation of sardine in some of the stock areas (WGANSA 2011). The 2013 survey may also have underestimated sardine abundance in some stock areas although the bias was probably small and had a negligible effect on the assessment according to the sensitivity tests. The age compositions of both the 2011 and 2013 acoustic surveys seem to be consistent with those from previous surveys as shown by the year-class curves (section 7.3.2).

Uncertainties in the assessment relating to the extent of sardine movement across the northern stock boundary still apply. The high abundance of Age 1 sardine in the Bay of Biscay in 2012 (together with the low abundance in the Iberian area) and the increase in Spanish catches in the eastern part of the Cantabrian Sea suggest that mixing between sardine from the two stocks may have been higher this year.

7.6 Short term predictions (Divisions VIIIc and IXa)

Catch predictions are carried out following the Stock Annex, apart from the assumptions about recruitment.

Recruitment (Age 0) estimated in the final year of the assessment, 2012, was accepted for the projection since it is supported by the acoustic survey in the interim year.

Input values for 2013 and 2014 recruitments (Age0) were set equal to the geometric mean of the period 2008-2012, RGM(08-12) = 5446 million individuals, instead of using a geometric mean of the recruitments of the last 15 years, as indicated in the Stock Annex. This year's assumption is equal to that adopted in last year's assessment. As argued last year, the assessment indicates the last strong recruitment was in 2004. Since then, no strong recruitments were observed. The last recruitment estimates, 2008 – 2012, are at a low level. There is a declining trend in the recruitment time series (Figure 7.5.2.5.). The WG considers that the possibility that low recruitments continue in the near future should be taken into account in the short term predictions. Therefore, a low recruitment, corresponding to the geometric mean of the last five years, 2008 – 2012, is assumed for 2013 – 2014. The 2012 recruitment was included in the geometric mean since it is supported by the acoustic survey in 2013.

Input values for weights-at-age in the stock and in the catch are mean values of the last three years (2010-2012) as indicated in the Stock Annex. Historical weights at age show an increase over time reflecting an improvement of sardine condition (Silva et al. *in press*). In this situation, an average of the most recent weights at age (2010-2012) was considered to be representative of weights at age in the short term. The assessment assumes the exploitation pattern is fixed over time since 1991 and that it is equal for ages 3-5 years. The exploitation pattern estimated by the assessment since 1991 was considered to apply in the short term. Natural mortality-at-age is assumed to be equal to that used in the assessment.

As indicated in the Stock annex, predictions were carried out with an $F_{multiplier}$ assuming an F_{sq} equal to the average estimate of the last three years in the assessment (F_{sq}=0.45). Fsq is applied to the interim year as well.

Input values are shown in **Table 7.6.**1 and results are shown in **Table 7.6.2**.

7.7 Reference points and harvest control rules for management purposes

Reference points for this stock were re-visited within a sub-group from WGHANSA who worked by correspondence in the interim period since the previous meeting. The sub-group came up with the following proposal of reference points (WDSilva et al. 2013): Bloss (306 thousand t, corresponding to B1+ in year 2000 estimated in the WGHANSA2012 assessment) is proposed as a proxy for Blim. In this assessment B1+ in year 2000 is estimated to be 305 thousand t thefore, very close to the proposed Blim. F= 0.27, corresponding to a Prob(B<Blim)<15% under equilibrium, as a proxy for Fmsy, assuming the low productivity scenario (since 1993) will continue in the future. This F provides high yield conditional to a low probability that the biomass falls below Blim=Bloss in equilibrium, thus incorporating precautionary considerations. The WG approved the above reference points.

A Workshop was set up by ICES to answer a request from the EU Commission to ICES for advice on whether a multiannual management plan developed by Portugal and Spain is consistent with ICES precautionary approach in the long term (WKSardineMP; ICES, 2013). The management plan was a rule where the TAC is set at a fixed level (86 thousand t), but reduced if the biomass (B1+) is below a trigger B1 (368.4 thousand t), and the fishery is stopped at B1+ below another reference point B0 (135 thousand t). The performance of the rule was examined with the HCS software, conditioned according to the results of the 2012 stock assessment by WGHANSA, and in relation to reference points Blim and FMSY that were proposed in WDSilva et al. 2013. The proposed rule gave a long-term risk to Blim of 13%. It is argued that this still may be acceptable because of the nature of the Blim as Bloss from a period with moderate exploitation, and because a high probability of rapid recovery when SSB falls below Blim could be demonstrated. The performance of the rule in terms of stability of catches and stock recovery by 2015 was also examined. By 2015, the probability of B1+ <Blim was at the long-term level. The stability may not be satisfactory from a stakeholder perspective, since the rule occasionally will prescribe drastic changes in the TAC. Alternative rules were briefly examined to give an indication of possible future improvements, but not to a stage where specific alternatives could be proposed.

The report of the Workshop will be revised in RG/ADGHANSA 2013 and evaluated by ACOM in July 2013.

7.8 Management considerations

There is no international TAC. A multiannual management plan for the Iberian sardine is being evaluated by ICES (Section 7.7).

The stock is managed by Portugal and Spain through minimum landing size, maximum daily catch, days fishing limitations, and closed areas (see Stock Annex).

Since 2010, annual catch limits are set for the Portuguese fishery by the Portuguese authorities. In 2012, the catch limit was 36 thousand t and was set in two steps: 9 thousand t for 1 January-31 May and 27 thousand t for 1 June-31 December (Despacho n.º 1517/2012, DR 2.ª série, 23, 1 February 2012; Despacho n.º 7509/2012, DR 2.ª série, 106, 31 May 2012). Fishing for sardine was banned for 45 days during the first quarter of the year with different regional periods. In 2013, limits of 12 thousand t and 15 thousand t were set for 1 January-31 May and 1 June-31 August, respectively (Despacho n.º 15351-A/2012, DR, 2.ª série, 232, 30 November 2012; Despacho n.º 7112-A/2013, DR, 2.ª série, 105, 31 de May 2013).

B1+ at the beginning of 2012, 185 thousand t is 40% below Bloss= 306 thousand t (proposed as Blim). Fsq=0.45 is 66% above the proposed Fmsy. The assessment indicates a 40% decrease in B1+ and a 33% decrease of F from 2011 to 2012 which reflects the drop in catches (32%).

Catch levels have been broadly stable in the past decade such that F fluctuates inversely to the stock biomass. The historical fishing mortality shows fluctuations around the mean value of =0.33, i.e. at the level of $M_{2\text{-}5}$=0.30 and slightly above the proposed Fmsy. This means that the stock has tolerated periods of exploitation above Fmsy since 1978. F has increased since 2008 and shows values above the historical range in 2010 and 2011.

The stock biomass shows a declining trend since 2006 due to the lack of strong recruitments. According to the short term predictions, assuming recruitment remains low in 2013, the stock will continue to decline. It is noted that, at present, the development of the stock is mainly dependent on the strength of the incoming recruitment. In the recent past, large recruitments were produced by very low spawning biomasses (e.g. in 2000, the year corresponding to Bloss, the proposed Blim).

7.9 Reply to reviewers comments

Most general and technical comments from the reviewers were taken into account. Single fleet runs were suggested by the reviewers but are not presented since they were presented at the 2012 benchmark.

With respect to the selectivity pattern: F-at-age and reference F's reported in WGHANSA 2012 were calculated as –LN(Na+1,t+1/Na,t) minus M from the model estimates of population N-at-age; however, to calculate Z for age 5 (maxage-1), SS3 includes numbers for the 6+ group in the same year, i.e. –LN(N6,y+1/(N5,y+N6,y)). Fs for age 5 and consequentely mean F(2-5) are therefore misreported in WGHANSA 2012. The correct Fs for age 5 and reference Fs were calculated tin this assessment, multiplying age5-selectivity by apical F by year. The correct F-reference is higher than the F-reference in WGHANSA 2012 with differences of 2-7% up to 1990 and 7-18% since 1991.

7.10 Indicators and thresholds to trigger new advice.

There is at present no coordinated survey to assess sardine recruitment (a Portuguese autumn survey was discontinued in 2008) although in recent years, both Portugal and Spain have carried out surveys to assess recruitment. Given the low level of the stock, the dynamics of the stock and therefore the short term catch options for the fishery are almost exclusively determined by the strength of the incoming recruitment. In case there is data from an autumn recruitment, these data could be evaluated within an ICES sub-group (e.g. working by correspondence) to decide if the advice should be re-opened.

Table 7.2.1.1: Sardine in VIIIc and IXa: Spanish fleet that operates in the purse seine fishery in 2012 and Portuguese composition of the fleet licensed to catch sardine in 2012. Dimensions average (units), Engine power average in HP.

Country	Details given	DIMENSIONS	Engine power (Horse Power)	Gear	Storage	Discard estimates	No vessels
Spain (northern)	yes	18 (meters)	233	Purse seine	Dry hold with ice	No	165
Spain (Gulf of Cadiz)	yes	17 (meters)	181	Purse seine	Dry hold with ice	No	76
Portugal	yes	44.5 (GT)	224	Purse seine	Dry hold with ice	No	118

Table 7.2.2.1: Sardine in VIIIc and IXa: Quaterly distribution of sardine landings (t) in 2012 by ICES Sub-Division. Above absolute values; below, relative numbers.

Sub-Div	1st	2nd	3rd	4th	Total
VIIIc-E	5183	2043	166	2159	**9551**
VIIIc-W	351	743	1884	561	**3539**
IXa-N	796	1389	1096	874	**4154**
IXa-CN	1358	3708	6806	7775	**19647**
IXa-CS	2246	1819	2125	2855	**9045**
IXa-S (A)	550	744	1285	312	**2891**
IXa-S (C)	731	1138	2447	1715	**6031**
Total	**11214**	**11583**	**15809**	**16251**	**54857**

Sub-Div	1st	2nd	3rd	4th	Total
VIIIc-E	9.45	3.72	0.30	3.94	**17.41**
VIIIc-W	0.64	1.35	3.44	1.02	**6.45**
IXa-N	1.45	2.53	2.00	1.59	**7.57**
IXa-CN	2.47	6.76	12.41	14.17	**35.81**
IXa-CS	4.09	3.32	3.87	5.21	**16.49**
IXa-S (A)	1.00	1.36	2.34	0.57	**5.27**
IXa-S (C)	1.33	2.07	4.46	3.13	**10.99**
Total	**20.44**	**21.12**	**28.82**	**29.62**	

Table 7.2.2.2. WG Estimates. Sardine in VIIIc and IXa: Iberian Sardine Landings (tonnes) by subarea and total for the period 1940-2012.

	Sub-area							
Year	VIIIc	IXa North	IXa Central North	IXa Central South	IXa South Algarve	IXa South Cadiz	All sub-areas	Div. IXa
1940	66816		42132	33275	23724		**165947**	**99131**
1941	27801		26599	34423	9391		**98214**	**70413**
1942	47208		40969	31957	8739		**128873**	**81665**
1943	46348		85692	31362	15871		**179273**	**132925**
1944	76147		88643	31135	8450		**204375**	**128228**
1945	67998		64313	37289	7426		**177026**	**109028**
1946	32280		68787	26430	12237		**139734**	**107454**
1947	43459	21855	55407	25003	15667		**161391**	**117932**
1948	10945	17320	50288	17060	10674		**106287**	**95342**
1949	11519	19504	37868	12077	8952		**89920**	**78401**
1950	13201	27121	47388	17025	17963		**122698**	**109497**
1951	12713	27959	43906	15056	19269		**118903**	**106190**
1952	7765	30485	40938	22687	25331		**127206**	**119441**
1953	4969	27569	68145	16969	12051		**129703**	**124734**
1954	8836	28816	62467	25736	24084		**149939**	**141103**
1955	6851	30804	55618	15191	21150		**129614**	**122763**
1956	12074	29614	58128	24069	14475		**138360**	**126286**
1957	15624	37170	75896	20231	15010		**163931**	**148307**
1958	29743	41143	92790	33937	12554		**210167**	**180424**
1959	42005	36055	87845	23754	11680		**201339**	**159334**
1960	38244	60713	83331	24384	24062		**230734**	**192490**
1961	51212	59570	96105	22872	16528		**246287**	**195075**
1962	28891	46381	77701	29643	23528		**206144**	**177253**
1963	33796	51979	86859	17595	12397		**202626**	**168830**
1964	36390	40897	108065	27636	22035		**235023**	**198633**
1965	31732	47036	82354	35003	18797		**214922**	**183190**
1966	32196	44154	66929	34153	20855		**198287**	**166091**
1967	23480	45595	64210	31576	16635		**181496**	**158016**
1968	24690	51828	46215	16671	14993		**154397**	**129707**
1969	38254	40732	37782	13852	9350		**139970**	**101716**
1970	28934	32306	37608	12989	14257		**126094**	**97160**
1971	41691	48637	36728	16917	16534		**160507**	**118816**
1972	33800	45275	34889	18007	19200		**151171**	**117371**
1973	44768	18523	46984	27688	19570		**157533**	**112765**
1974	34536	13894	36339	18717	14244		**117730**	**83194**
1975	50260	12236	54819	19295	16714		**153324**	**103064**
1976	51901	10140	43435	16548	12538		**134562**	**82661**
1977	36149	9782	37064	17496	20745		**121236**	**85087**
1978	43522	12915	34246	25974	23333	5619	**145609**	**102087**
1979	18271	43876	39651	27532	24111	3800	**157241**	**138970**
1980	35787	49593	59290	29433	17579	3120	**194802**	**159015**
1981	35550	65330	61150	37054	15048	2384	**216517**	**180967**
1982	31756	71889	45865	38082	16912	2442	**206946**	**175190**
1983	32374	62843	33163	31163	21607	2688	**183837**	**151463**
1984	27970	79606	42798	35032	17280	3319	**206005**	**178035**
1985	25907	66491	61755	31535	18418	4333	**208439**	**182532**
1986	39195	37960	57360	31737	14354	6757	**187363**	**148168**
1987	36377	42234	44806	27795	17613	8870	**177696**	**141319**
1988	40944	24005	52779	27420	13393	2990	**161531**	**120587**
1989	29856	16179	52585	26783	11723	3835	**140961**	**111105**
1990	27500	19253	52212	24723	19238	6503	**149429**	**121929**
1991	20735	14383	44379	26150	22106	4834	**132587**	**111852**
1992	26160	16579	41681	29968	11666	4196	**130250**	**104090**

1993	24486	23905	47284	29995	13160	3664	**142495**	**118009**
1994	22181	16151	49136	30390	14942	3782	**136582**	**114401**
1995	19538	13928	41444	27270	19104	3996	**125280**	**105742**
1996	14423	11251	34761	31117	19880	5304	**116736**	**102313**
1997	15587	12291	34156	25863	21137	6780	**115814**	**100227**
1998	16177	3263	32584	29564	20743	6594	**108924**	**92747**
1999	11862	2563	31574	21747	18499	7846	**94091**	**82229**
2000	11697	2866	23311	23701	19129	5081	**85786**	**74089**
2001	16798	8398	32726	25619	13350	5066	**101957**	**85159**
2002	15885	4562	33585	22969	10982	11689	**99673**	**83787**
2003	16436	6383	33293	24635	8600	8484	**97831**	**81395**
2004	18306	8573	29488	24370	8107	9176	**98020**	**79714**
2005	19800	11663	25696	24619	7175	8391	**97345**	**77545**
2006	15377	10856	30152	19061	5798	5779	**87023**	**71646**
2007	13380	12402	41090	19142	4266	6188	**96469**	**83088**
2008	13636	9409	45210	20858	4928	7423	**101464**	**87828**
2009	11963	7226	36212	20838	4785	6716	**87740**	**75777**
2010	13772	7409	40923	17623	5181	4662	**89571**	**75798**
2011	8536	5621	37152	13685	6387	9023	**80403**	**71867**
2012	13090	4154	19647	9045	2891	6031	**54857**	**41768**

Table 7.2.4.1: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in 2012.

				Total				
Length	**VIIIc E**	**VIIIc W**	**IXa N**	**IXa CN**	**IXa CS**	**IXa S**	**IXa S (Ca)**	**Total**
6.5								
7								
7.5								
8								
8.5								
9								
9.5								
10	2 294	1 200					693 840	697 334
10.5	11 264	5 891					1040 760	1057 915
11	14 229	7 258					5217 427	5238 914
11.5	45 889	23 817	2 346				9457 929	9529 981
12	153 922	80 201	13 247				15477 814	15725 184
12.5	249 036	129 640	10 558	168			14723 240	15112 641
13	239 518	126 696	33 836	296			11830 352	12230 698
13.5	166 067	78 380	49 040	1 740	7		12644 323	12939 557
14	250 703	70 790	56 497	4 286	330		14833 301	15215 907
14.5	285 965	30 681	83 286	6 029	1 371		12223 013	12630 345
15	185 812	31 051	387 639	14 416	2 778	5	12873 149	13494 851
15.5	380 563	41 464	1094 661	19 479	2 077	1	14134 699	15672 944
16	408 700	32 755	2017 268	26 588	3 900	31	12964 905	15454 146
16.5	1068 235	22 895	4017 055	16 738	2 497	35	12509 563	17637 018
17	1840 700	89 680	6038 137	16 784	1 380	379	9643 460	17630 521
17.5	2963 577	103 106	4446 393	11 226	1 712	964	9859 281	17386 260
18	3785 956	162 688	2797 329	9 030	2 826	1 975	7382 057	14141 861
18.5	4888 972	267 760	2122 422	12 893	4 671	2 304	4761 787	12060 809
19	6676 688	776 223	3153 481	26 748	8 354	2 548	3517 839	14161 882
19.5	7295 943	892 616	4150 303	33 290	12 368	3 626	2645 328	15033 474
20	11711 319	1602 420	4841 038	32 750	18 321	5 353	1485 473	19696 675
20.5	14356 964	1888 825	5740 058	33 049	17 558	6 366	442 366	22485 186
21	18706 174	2939 857	5064 204	27 811	18 929	6 291	275 766	27039 032
21.5	15884 495	4986 939	5352 287	16 435	14 565	4 016	224	26258 961
22	15506 032	6634 888	4188 136	10 101	8 868	1 583	157	26349 764
22.5	9038 317	6121 414	2116 883	3 172	3 277	428	157	17283 648
23	6142 240	4781 339	1210 626	863	1 431	78		12136 577
23.5	2297 433	2398 558	616 274	595	288			5313 148
24	678 087	1269 999	194 188	170	112			2142 557
24.5	271 963	278 603	82 599	83				633 248
25	26 819	180 138	46 212					253 169
25.5	44 116	46 969						91 085
26	3 004	20 333						23 337
26.5								
27								
27.5								
28								
28.5								
29								
Total	125580 996	36125 074	59926 003	324 742	127 621	35 984	190638 210	412 758 631
Mean L	20.9	22.0	19.6	18.9	20.2	20.4	15.0	18.1
sd	1.78	1.73	2.14	2.26	1.86	1.22	2.28	3.58
Catch	**9551**	**3539**	**4154**	**19647**	**9045**	**2891**	**6031**	**54857**

Table 7.2.4.1a: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in the first quarter 2012.

				First Quarter				
Length	**VIIIc E**	**VIIIc W**	**IXa N**	**IXa CN**	**IXa CS**	**IXa S**	**IXa S (Ca)**	**Total**
6.5								
7								
7.5								
8								
8.5								
9								
9.5								
10								
10.5								
11	353							353
11.5	353							353
12	588							588
12.5	1 177						35 663	36 840
13	1 177	2 128					693 383	696 688
13.5	20 877	2 630			7		2016 549	2040 063
14	132 904	9 558	5 948		7		3041 967	3190 384
14.5	235 396	5 985	45 723		15		3332 824	3619 943
15	132 245	6 188	189 715			5	3614 464	3942 617
15.5	328 485	21 426	559 570		10	1	2460 589	3370 080
16	359 079	9 472	1362 573		158	30	1977 720	3709 032
16.5	954 703	6 676	2775 259		162	23	1485 187	5222 009
17	1636 698	5 482	4121 303		10	58	534 289	6297 839
17.5	2596 905	5 349	2577 544		191	82	1022 730	6202 800
18	3020 757	6 340	1045 338		548	254	1034 164	5107 401
18.5	3971 719	11 245	474 924	478	1 246	465	523 414	4983 491
19	4320 666	35 668	672 961	807	2 453	668	596 266	5629 489
19.5	4909 136	44 058	904 638	2 142	4 900	915	734 399	6600 188
20	6803 832	82 725	934 511	3 377	7 639	1 469	835 002	8668 554
20.5	8549 187	141 003	736 905	2 893	6 283	1 529	167 767	9605 567
21	9951 341	211 092	384 785	3 284	5 548	1 596	167 767	10725 413
21.5	8639 390	312 924	58 654	2 600	3 806	1 026		9018 401
22	7117 226	511 738	34 694	1 925	2 306	193		7668 083
22.5	4510 199	580 224	19 316	555	494	82		5110 871
23	2715 543	688 098		91	298	22		3404 052
23.5	1021 418	616 947		338	125			1638 829
24	363 403	360 425		83				723 911
24.5	209 163	120 120		83				329 366
25	26 819	44 074						70 893
25.5	1 820	6 640						8 460
26	3 004	15 562						18 566
26.5								
27								
27.5								
28								
28.5								
29								
Total	72535 563	3863 775	16904 361	18 656	36 205	8 415	24274 144	117 641 119
Mean L	20.6	22.7	17.8	21.0	20.6	20.4	15.9	19.3
sd	1.76	1.57	1.46	1.08	1.10	1.11	1.89	2.67
Catch	**5 183**	**351**	**796**	**1 358**	**2 246**	**550**	**731**	**11 214**

Table 7.2.4.1b: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in the second quarter 2012.

				Second Quarter				
Length	**VIIIc E**	**VIIIc W**	**IXa N**	**IXa CN**	**IXa CS**	**IXa S**	**IXa S (Ca)**	**Total**
7								
7.5								
8								
8.5								
9								
9.5								
10								
10.5								
11								
11.5								
12								
12.5	3							3
13	179							179
13.5	365						102 318	102 683
14	730						204 637	205 367
14.5	1 949			24			468 721	470 694
15	3 148		6 862	446			1275 485	1285 941
15.5	9 118		14 049	1 806			3264 189	3289 162
16	9 815		14 049	5 626			4278 824	4308 314
16.5	74 129		324 547	8 487	19	12	6222 081	6629 275
17	70 792		512 414	10 598	38	131	5193 926	5787 899
17.5	110 487		516 580	8 695	118	350	3564 308	4200 537
18	266 596		645 343	6 778	517	768	1828 260	2748 262
18.5	364 701		798 625	4 649	972	911	759 700	1929 558
19	801 989	61 137	1253 321	6 595	2 391	865	344 468	2470 766
19.5	778 435	122 274	1612 054	5 899	2 760	943	230 722	2753 088
20	2017 216	305 686	1512 443	5 673	3 782	1 462	52 149	3898 410
20.5	2734 654	489 097	1952 032	3 757	3 453	1 791	537	5185 320
21	3635 639	427 960	2195 833	2 618	3 864	1 484	268	6267 666
21.5	3627 391	1161 606	2996 681	1 300	2 921	699	67	7790 666
22	3764 786	1528 429	2329 816	463	2 008	398		7625 899
22.5	2854 879	1895 251	1047 560		1 125	17		5798 833
23	1962 859	917 058	246 695	53	490	6		3127 161
23.5	758 743	611 372	83 135		31			1453 281
24	183 804	305 686	20 973					510 463
24.5	28 941		22 221					51 162
25			22 221					22 221
25.5	20 410							20 410
26								
26.5								
27								
27.5								
28								
28.5								
29								
Total	24081 758	7825 556	18127 454	73 465	24 489	9 838	27790 660	77933 220
Mean L	21.6	22.3	20.7	18.4	20.7	20.1	16.9	19.7
sd	1.30	1.03	1.58	1.58	1.18	1.23	1.00	2.53
Catch	**2 043**	**743**	**1 389**	**3 708**	**1 819**	**744**	**1 138**	**11 583**

Table 7.2.4.1c: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in the third quarter 2012.

			Third Quarter					
Length	**VIIIc E**	**VIIIc W**	**IXa N**	**IXa CN**	**IXa CS**	**IXa S**	**IXa S (Ca)**	**Total**
6.5								
7								
7.5								
8								
8.5								
9								
9.5								
10							693 840	693 840
10.5							1040 760	1040 760
11							5203 801	5203 801
11.5			2 346				9442 021	9444 367
12			12 904				15451 775	15464 679
12.5			10 558	168			14364 565	14375 291
13			33 493	61			10469 268	10502 822
13.5			49 040	91			8853 590	8902 721
14			49 862	46			7208 775	7258 683
14.5	1 405		24 931	1 153			4826 312	4853 801
15	2 884		27 102	2 568			4057 895	4090 449
15.5	4 650		22 585	2 684			4751 541	4781 460
16	7 247	6 252	66 329	2 507			2345 084	2427 419
16.5	8 393		185 437	2 172			1218 372	1414 374
17	11 381	20 475	638 728	852	27	187	653 107	1324 757
17.5	13 800	9 804	877 250	450		524	1065 399	1967 227
18	20 095	22 544	594 840	1 089	177	924	1232 691	1872 359
18.5	50 432	65 541	546 330	6 125	137	875	1473 188	2142 628
19	72 089	143 977	929 301	13 459	608	938	1741 613	2901 985
19.5	57 171	305 670	917 078	17 068	1 038	1 564	1241 777	2541 366
20	149 771	525 751	996 395	11 993	2 031	1 928	452 578	2140 447
20.5	152 881	704 772	1101 372	13 247	2 982	2 520	122 080	2099 854
21	222 157	1448 155	1410 460	10 727	5 569	2 226	106 156	3205 450
21.5	290 494	2779 991	1713 680	4 960	4 621	1 590		4795 335
22	256 015	3632 477	1500 659	1 943	3 126	628		5394 847
22.5	235 304	3100 688	768 492	836	1 122	232		4106 673
23	117 601	2771 392	293 766	171	415	38		3183 383
23.5	43 603	1041 266	41 104		45			1126 018
24	4 850	537 970			112			542 932
24.5	1 068	141 333	23 991					166 392
25		136 064	23 991					160 055
25.5		28 882						28 882
26		4 771						4 771
26.5								
27								
27.5								
28								
28.5								
29								
Total	1723 290	17427 776	12862 024	94 367	22 010	14 174	98016 188	130159 829
Mean L	21.4	22.3	20.3	19.6	21.3	20.3	13.7	15.6
sd	1.47	1.11	1.95	1.75	0.96	1.26	2.06	3.90
Catch	**166**	**1 884**	**1 096**	**6 806**	**2 125**	**1 285**	**2 447**	**15 809**

Table 7.2.4.1d: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in the fourth quarter 2012.

				Fourth Quarter				
Length	**VIIIc E**	**VIIIc W**	**IXa N**	**IXa CN**	**IXa CS**	**IXa S**	**IXa S (Ca)**	**Total**
7								
7.5								
8								
8.5								
9								
9.5								
10	2 294	1 200						3 494
10.5	11 264	5 891						17 155
11	13 876	7 258					13 626	34 760
11.5	45 536	23 817					15 908	85 261
12	153 334	80 201	343				26 039	259 917
12.5	247 856	129 640					323 012	700 508
13	238 162	124 568	343	236			667 701	1031 010
13.5	144 825	75 750		1 649			1671 866	1894 090
14	117 069	61 232	687	4 240	323		4377 922	4561 473
14.5	47 215	24 696	12 632	4 852	1 357		3595 156	3685 908
15	47 535	24 863	163 960	11 402	2 778		3925 305	4175 843
15.5	38 310	20 038	498 457	14 989	2 067	1	3658 380	4232 242
16	32 559	17 030	574 317	18 456	3 742	1	4363 277	5009 382
16.5	31 010	16 219	731 812	6 080	2 315	1	3583 923	4371 360
17	121 830	63 722	765 692	5 334	1 305	4	3262 138	4220 026
17.5	242 386	87 953	475 019	2 082	1 404	8	4206 844	5015 696
18	478 508	133 805	511 808	1 164	1 584	29	3286 942	4413 839
18.5	502 120	190 974	302 543	1 642	2 315	53	2005 485	3005 132
19	1481 944	535 440	297 898	5 888	2 902	78	835 492	3159 642
19.5	1551 200	420 614	716 533	8 181	3 670	204	438 430	3138 833
20	2740 501	688 258	1397 689	11 707	4 869	495	145 744	4989 263
20.5	2920 242	553 952	1949 749	13 152	4 840	527	151 982	5594 445
21	4897 037	852 649	1073 126	11 182	3 948	985	1 575	6840 502
21.5	3327 219	732 419	583 272	7 574	3 217	700	157	4654 559
22	4368 005	962 244	322 967	5 770	1 428	365	157	5660 936
22.5	1437 934	545 251	281 515	1 782	537	96	157	2267 272
23	1346 237	404 791	670 165	549	228	12		2421 982
23.5	473 669	128 972	492 035	257	87			1095 020
24	126 030	65 919	173 215	87				365 251
24.5	32 791	17 151	36 387					86 329
25								
25.5	21 886	11 447						33 333
26								
26.5								
27								
27.5								
28								
28.5								
29								
Total	27240 384	7007 968	12032 164	138 254	44 917	3 557	40557 218	87024 462
Mean L	20.9	20.5	19.9	18.3	19.	21.1	16.3	18.6
sd	2.04	2.63	2.33	2.63	2.3	.91	1.64	2.92
Catch	**2 159**	**561**	**874**	**7 775**	**2 855**	**312**	**1 715**	**16 251**

Table 7.2.4.2: Sardine in VIIIc and IXa: Catch in numbers (thousands) at age by quarter and by subdivision in 2012.

							First Quarter	
Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
0		133						
1	6 793	279	12 629		427	22	16 475	36 625
2	10 756	926	2 476	1 490	5 368	749	4 737	26 503
3	10 179	739	1 499	6 638	12 722	641	1 553	33 972
4	25 913	550	105	3 437	7 347	1 844	1 060	40 255
5	14 748	454	78	2 161	3 441	2 097	213	23 193
6	1 620	423	74	1 701	1 695	1 446	194	7 154
7	1 196	206	34	1 023	2 905	852	42	6 259
8	1 009	83	9	2 206	2 030	617		5 953
9	321	71			95			487
10					174	147		322
11								
12								
Total	72 536	3 864	16 904	18 656	36 205	8 415	24 274	180 722
Catch (Tons)	5 183	351	796	1 358	2 246	550	731	11 214

							Second Quarter	
Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
0								
1	859	129	3 399	23 402	409	265	14 457	42 919
2	2 014	748	3 720	36 908	5 111	2 551	10 689	61 741
3	2 373	2 537	6 996	10 996	6 331	835	2 161	32 229
4	9 702	1 664	1 482	893	4 314	2 525	386	20 966
5	6 745	1 088	781		2 584	1 473	63	12 734
6	862	679	743	637	1 945	1 099	36	6 001
7	802	638	718	305	2 030	519		5 014
8	629	224	287	259	1 765	346		3 510
9	95	78		65		167		405
10		40				58		98
11								
12								
Total	24 082	7 826	18 127	73 465	24 489	9 838	27 791	185 618
Catch (Tons)	2 043	743	1 389	3 708	1 819	744	1 138	11 583

							Third Quarter	
Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
0	216	123	3 100	12 301	95	52	88 476	104 363
1	244	1 975	3 328	42 578	1 242	1 307	5 446	56 121
2	267	3 643	2 344	26 672	5 394	2 135	3 496	43 951
3	239	6 057	1 812	10 561	5 005	2 442	331	26 448
4	452	3 530	801	832	4 106	3 120	131	12 971
5	240	831	408	149	2 306	2 501	82	6 518
6	58	529	503	587	1 953	2 616	39	6 285
7	7	375	449	441	1 380		15	2 667
8		364	118		487			969
9				246				246
10					42			42
11								
12								
Total	1 723	17 428	12 862	94 367	22 010	14 174	98 016	260 580
Catch (Tons)	166	1 884	1 096	6 806	2 125	1 285	2 447	15 809

							Fourth Quarter	
Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
0	3 189	884	3 995	69 489	14 982	2	23 260	115 801
1	3 222	1 921	3 296	27 232	9 948	60	12 688	58 366
2	4 419	1 501	1 810	16 826	7 255	427	4 318	36 556
3	4 675	1 613	970	16 283	5 975	445	180	30 141
4	7 941	702	533	5 610	3 402	1 518	55	19 761
5	3 055	170	366	892	1 193	452	31	6 160
6	612	106	405	1 196	724	393	16	3 452
7	128	56	518	184	1 241	167	9	2 302
8		56	139	485	197	93		970
9								
10				56				56
11								
12								
Total	27 240	7 008	12 032	138 254	44 917	3 557	40 557	273 566
Catch (Tons)	2 159	561	874	7 775	2 855	312	1 715	16 251

							Whole Year	
Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
0	3 405	1 007	7 094	81 790	15 077	55	111 736	220 164
1	11 118	4 158	22 652	93 212	12 026	1 653	49 066	193 884
2	17 457	6 171	10 350	81 896	23 129	5 862	23 240	168 105
3	17 466	11 134	11 277	44 479	30 033	4 362	4 225	122 976
4	44 008	6 635	2 921	10 772	19 170	9 006	1 632	94 143
5	24 788	2 639	1 633	3 203	9 524	6 524	389	48 700
6	3 152	1 768	1 726	4 121	6 316	5 554	285	22 923
7	2 133	1 493	1 719	1 954	7 557	1 539	66	16 460
8	1 638	849	553	2 949	4 479	1 057		11 525
9	416	160		311	95	167		1 150
10		111		56	216	205		588
11								
12								
Total	125 581	36 125	59 926	324 742	127 621	35 984	190 638	900 618
Catch (Tons)	9 551	3 539	4 154	19 647	9 045	2 891	6 031	54 857

Table 7.2.4.3: Sardine in VIIIc and IXa: Relative distribution of sardine catches. Upper pannel, relative contribution of each group within each subdivision. Lower pannel, relative contribution of each subdivision within each Age Group.

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	Xa-S (Ca)	Total
0	3%	3%	12%	25%	12%	0%	59%	24%
1	9%	12%	38%	29%	9%	5%	26%	22%
2	14%	17%	17%	25%	18%	16%	12%	19%
3	14%	31%	19%	14%	24%	12%	2%	14%
4	35%	18%	5%	3%	15%	25%	1%	10%
5	20%	7%	3%	1%	7%	18%	0%	5%
6+	6%	12%	7%	3%	15%	24%	0%	6%
	100%	100%	100%	100%	100%	100%	100%	100%

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	Xa-S (Ca)	Total
0	2%	0%	3%	37%	7%	0%	51%	100%
1	6%	2%	12%	48%	6%	1%	25%	100%
2	10%	4%	6%	49%	14%	3%	14%	100%
3	14%	9%	9%	36%	24%	4%	3%	100%
4	47%	7%	3%	11%	20%	10%	2%	100%
5	51%	5%	3%	7%	20%	13%	1%	100%
6+	14%	8%	8%	18%	35%	16%	1%	100%

Table 7.2.4.4: Sardine VIIIc and IXa: Historical catch-at-age data.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6+
1978	869	2297	947	295	137	42	16
1979	674	1536	956	431	189	93	36
1980	857	2037	1562	379	157	47	30
1981	1026	1935	1734	679	195	105	76
1982	62	795	1869	709	353	131	129
1983	1070	577	857	803	324	141	139
1984	118	3312	487	502	301	179	117
1985	268	564	2371	469	294	201	103
1986	304	755	1027	919	333	196	167
1987	1437	543	667	569	535	154	171
1988	521	990	535	439	304	292	189
1989	248	566	909	389	221	200	245
1990	258	602	517	707	295	151	248
1991	1581	477	436	407	266	75	105
1992	498	1002	451	340	186	111	81
1993	88	566	1082	521	257	114	120
1994	121	60	542	1094	272	113	72
1995	31	189	281	830	473	70	64
1996	277	101	348	515	653	197	47
1997	209	549	453	391	337	225	70
1998	449	366	502	352	234	179	106
1999	246	475	362	340	177	106	73
2000	490	355	314	256	194	98	64
2001	220	1172	256	196	126	75	50
2002	107	587	754	181	112	56	40
2003	198	319	446	518	114	61	51
2004	590	181	264	387	378	78	55
2005	169	1006	266	207	191	117	46
2006	18	250	777	129	108	121	81
2007	199	82	313	536	80	83	121
2008	298	219	183	370	412	65	109
2009	378	354	196	125	252	197	84
2010	278	517	263	136	83	129	183
2011	342	452	383	122	88	41	111
2012	220	194	168	123	94	49	53

Table 7.2.5.1: Sardine VIIIc and IXa: Sardine Mean length (cm) at age by quarter and by subc in 2012.

First Quarter

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)
0							
1	18.1	17.6	17.2		16.6	16.2	15.1
2	19.0	21.2	18.9	19.9	19.3	18.6	16.8
3	20.1	22.1	20.5	20.4	20.2	19.1	18.3
4	21.2	22.8	21.0	21.4	21.1	20.1	19.8
5	21.7	23.2	20.8	21.8	21.3	20.9	20.1
6	22.4	23.4	21.1	21.1	21.4	21.0	20.2
7	23.0	23.5	21.2	20.3	21.4	21.1	21.3
8	23.3	23.9	21.6	22.1	21.6	21.3	
9	24.7	24.2			21.8		
10		24.5			23.5	21.0	
11							
12							

Second Quarter

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)
0							
1	19.7	20.6	18.3	17.2	18.4	18.3	16.5
2	20.2	21.1	20.2	18.3	19.4	18.7	17.1
3	20.5	21.9	21.3	20.4	20.3	19.7	17.3
4	21.6	22.5	22.0	21.4	21.4	20.4	19.0
5	22.0	22.8	22.0		21.2	20.9	19.2
6	22.7	23.1	22.0	21.2	21.1	21.1	19.6
7	23.0	23.0	22.1	21.6	22.1	21.0	21.4
8	23.4	23.4	22.7	21.6	22.0	21.5	
9	24.7	23.1		21.8		22.0	
10		23.7				21.9	
11							
12							

Third Quarter

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)
0	19.4	19.5	17.7	15.9	18.1	17.8	13.2
1	20.2	20.9	20.0	19.6	19.6	18.2	17.8
2	21.0	22.0	21.1	20.7	20.7	19.0	19.1
3	22.1	22.4	21.8	21.3	21.5	19.8	20.0
4	22.3	22.9	22.1	21.8	21.7	20.7	20.0
5	22.3	23.0	22.4	22.3	21.7	20.9	20.1
6	22.5	23.1	22.3	21.9	21.8	21.9	20.5
7	23.9	23.7	22.4	21.9	21.9		21.0
8		23.6	22.4		22.2		
9				22.9			
10					22.8		
11							
12							

Fourth Quarter

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)
0	17.3	15.1	17.2	15.9	16.2	16.2	15.2
1	20.0	20.1	20.2	19.9	19.2	19.1	17.5
2	20.6	21.1	20.9	20.8	20.3	20.2	18.3
3	21.4	21.9	21.6	21.5	21.0	20.7	19.6
4	21.9	22.5	22.3	21.8	21.2	21.4	20.1
5	22.1	22.5	23.1	22.5	21.4	21.0	20.2
6	22.2	22.6	22.9	21.4	22.0	21.5	20.5
7	24.3	23.4	23.3	23.4	22.0	21.1	20.8
8		23.4	23.2	22.2	22.9	21.8	
9							
10				22.8			
11							
12							

Whole Year

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)
0	17.5	15.7	17.4	15.9	16.2	17.7	13.6
1	18.8	20.4	18.2	19.1	19.1	18.2	16.4
2	19.5	21.6	20.2	19.6	20.0	18.9	17.6
3	20.5	22.2	21.3	21.0	20.6	19.8	18.0
4	21.4	22.7	22.1	21.6	21.3	20.6	19.7
5	21.8	22.9	22.3	22.0	21.3	20.9	20.0
6	22.4	23.2	22.2	21.3	21.5	21.5	20.2
7	23.1	23.3	22.5	21.2	21.8	21.1	21.1
8	23.3	23.6	22.7	22.1	21.9	21.4	
9	24.7	23.7		22.7	21.8	22.0	
10		24.2		22.8	23.3	21.3	
11							
12							

Table 7.2.5.2: Sardine VIIIc and IXa: Sardine Mean weight (kg) at age by quarter and by sub
in 2012.

						First Quarter	
Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)
0							
1	0.048	0.047	0.042		0.034	0.039	0.025
2	0.055	0.076	0.055	0.062	0.052	0.053	0.035
3	0.065	0.084	0.068	0.068	0.059	0.056	0.043
4	0.077	0.092	0.073	0.077	0.066	0.063	0.054
5	0.082	0.096	0.071	0.081	0.068	0.068	0.056
6	0.089	0.098	0.074	0.073	0.069	0.069	0.057
7	0.096	0.099	0.075	0.066	0.069	0.070	0.065
8	0.100	0.104	0.079	0.085	0.071	0.071	
9	0.115	0.108			0.072		
10		0.112			0.089	0.070	
11							
12							

						Second Quarter	
Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)
0							
1	0.066	0.075	0.053	0.040	0.055	0.059	0.039
2	0.069	0.081	0.071	0.050	0.063	0.063	0.042
3	0.071	0.089	0.083	0.070	0.070	0.071	0.043
4	0.085	0.097	0.091	0.080	0.080	0.078	0.054
5	0.090	0.101	0.091		0.078	0.083	0.055
6	0.099	0.105	0.090	0.079	0.078	0.085	0.058
7	0.103	0.104	0.092	0.083	0.087	0.084	0.071
8	0.108	0.109	0.100	0.082	0.086	0.089	
9	0.128	0.105		0.085		0.095	
10		0.113				0.1	
11							
12							

						Third Quarter	
Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)
0	0.074	0.075	0.059	0.036	0.061	0.061	0.021
1	0.082	0.090	0.080	0.070	0.076	0.066	0.053
2	0.091	0.103	0.093	0.083	0.089	0.074	0.065
3	0.103	0.109	0.101	0.091	0.099	0.084	0.075
4	0.106	0.115	0.105	0.099	0.101	0.095	0.075
5	0.107	0.116	0.108	0.105	0.101	0.098	0.076
6	0.110	0.119	0.107	0.099	0.103	0.111	0.081
7	0.129	0.126	0.109	0.100	0.104		0.087
8		0.126	0.109		0.108		
9				0.116			
10					0.115		
11							
12							

						Fourth Quarter	
Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)
0	0.051	0.035	0.046	0.035	0.041	0.053	0.034
1	0.070	0.073	0.074	0.069	0.064	0.073	0.051
2	0.075	0.084	0.082	0.078	0.074	0.081	0.059
3	0.082	0.094	0.090	0.086	0.081	0.085	0.072
4	0.088	0.102	0.099	0.090	0.082	0.090	0.077
5	0.092	0.101	0.109	0.099	0.085	0.087	0.077
6	0.094	0.102	0.106	0.086	0.092	0.091	0.082
7	0.125	0.114	0.111	0.112	0.086	0.088	0.085
8		0.113	0.111	0.096	0.1	0.093	
9							
10				0.1			
11							
12							

						Whole Year	
Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)
0	0.061	0.040	0.052	0.035	0.041	0.061	0.024
1	0.064	0.080	0.054	0.062	0.064	0.064	0.039
2	0.067	0.095	0.074	0.067	0.070	0.067	0.047
3	0.077	0.100	0.084	0.080	0.072	0.077	0.047
4	0.083	0.107	0.096	0.086	0.080	0.083	0.056
5	0.084	0.105	0.098	0.087	0.081	0.084	0.062
6	0.094	0.107	0.098	0.082	0.085	0.094	0.062
7	0.077	0.109	0.102	0.081	0.083	0.077	0.072
8	0.079	0.115	0.104	0.086	0.082	0.079	
9	0.095	0.107		0.109	0.072	0.095	
10	0.1	0.112		0.102	0.094	0.076	
11							
12							

Table 7.3.2.1.1: Sardine in VIIIc and Ixa: Sardine Assessment from the 2013 Portuguese spring acoustic survey (PELAGO13). Numbers in thousands, biomass in tons.

		AGE						
AREA		**1**	**2**	**3**	**4**	**5**	**6+**	**Total**
Oc. Norte	**Biomass**	8414	498	118	84	11	49	9174
	%	91.7	5.4	1.3	0.9	0.1	0.5	100.0
	No fish	240950	9937	1961	1150	154	595	254748
	%	94.6	3.9	0.8	0.5	0.1	0.2	100.0
Oc. Sul	**Biomass**	37980	4524	7704	4000	7426	10653	72288
	%	52.5	6.3	10.7	5.5	10.3	14.7	100.0
	No fish	1090861	75747	121390	52998	98518	135172	1574688
	%	69.3	4.8	7.7	3.4	6.3	8.6	100.0
Algarve	**Biomass**	3219	1823	2042	497	961	949	9492
	%	33.9	19.2	21.5	5.2	10.1	10.0	100.0
	No fish	81668	38849	40660	7893	14247	13464	196781
	%	41.5	19.7	20.7	4.0	7.2	6.8	100.0
Cadiz	**Biomass**	16575	3388	914	108	49	15	21049
	%	78.7	16.1	4.3	0.5	0.2	0.1	100.0
	No fish	398705	73881	17826	1716	708	204	493039
	%	80.9	15.0	3.6	0.3	0.1	0.0	100.0
Total Portugal	**Biomass**	49614	6845	9865	4581	8398	11651	90954
	%	54.5	7.5	10.8	5.0	9.2	12.8	100.0
	No fish	1413480	124533	164011	62042	112920	149231	2026217
	%	69.8	6.1	8.1	3.1	5.6	7.4	100.0
Total	**Biomass**	66189	10233	10778	4690	8447	11666	112003
	%	59.1	9.1	9.6	4.2	7.5	10.4	100.0
	No fish	1812184	198414	181837	63757	113628	149435	2519256
	%	71.9	7.9	7.2	2.5	4.5	5.9	100.0

7.3.2.2.1. Sardine in VIIIc and IXa: sardine abundance in number (thousand of fish) and biomass (tons) by age groups and ICES subdivisión in PELACUS0413.

AREA VIIIcE											
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (Tonnes)	91	498	524	359	626	283	58	37	8		2484
% Biomass	3.7	20.0	21.1	14.5	25.2	11.4	2.4	1.5	0.3		100
Abundance (N in '000)	2851	9035	8638	4846	8095	3303	661	386	74		37888
% Abundance	7.5	23.8	22.8	12.8	21.4	8.7	1.7	1.0	0.2		100
Medium Weight (gr)	31.95	55.11	60.62	74.13	77.32	85.82	88.35	94.98	104.91		74.8
Medium Length (cm)	16.28	19.73	20.41	21.92	22.23	23.09	23.32	23.94	24.80		21.7

AREA VIIIcW											
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (Tonnes)	0	1	3	9	17	11	3	2	1		46
% Biomass	0.0	1.8	5.6	18.9	36.1	24.6	6.2	5.0	1.8		100
Abundance (N in '000)	0	12	33	106	195	125	31	24	8		534
% Abundance	0.0	2.2	6.1	19.9	36.5	23.5	5.8	4.5	1.5		100
Medium Weight (gr)	0.0	69.2	78.2	81.7	85.1	90.2	92.3	97.1	104.3		74.2
Medium Length (cm)	0.0	21.4	22.3	22.7	23.0	23.5	23.7	24.1	24.8		20.1

AREA IXaN											
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (Tonnes)	216	168	143	101	143	37	5	0			813
% Biomass	26.5	20.6	17.5	12.5	17.6	4.6	0.6	0.0			100
Abundance (N in '000)	6612	3004	2336	1432	1989	486	65	5			15929
% Abundance	41.5	18.9	14.7	9.0	12.5	3.1	0.4	0.0			100
Medium Weight (gr)	32.6	55.8	61.0	70.8	71.8	76.4	79.1	87.3			61.4
Medium Length (cm)	16.4	19.8	20.5	21.6	21.7	22.2	22.5	23.3			20.4

TOTAL SPAIN											
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (Tonnes)	307	666	669	469	785	332	66	39	9		3343
% Biomass	9.2	19.9	20.0	14.0	23.5	9.9	2.0	1.2	0.3		100
Abundance (N in '000)	9463	12050	11007	6384	10279	3914	757	415	82.5		54351
% Abundance	17.4	22.2	20.3	11.7	18.9	7.2	1.4	0.8	0.2		100
Medium Weight (gr)	32.4	55.3	60.8	73.5	76.4	84.8	87.7	95.0	104.8		74.5
Medium Length (cm)	16.4	19.8	20.4	21.9	22.1	23.0	23.3	23.9	24.8		21.7

Table 7.4.1a. Sardine in VIIIc and IXa: Mean weights-at-age (kg) in the catch. Weights-at-age 1978-1987 are fixed and equal to those in 1988. Age 6+ weight is fixed over time at 0.100 Kg.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6+
1988	0.017	0.034	0.052	0.060	0.068	0.072	0.100
1989	0.013	0.035	0.052	0.059	0.066	0.071	0.100
1990	0.024	0.032	0.047	0.057	0.061	0.067	0.100
1991	0.020	0.031	0.058	0.063	0.073	0.074	0.100
1992	0.018	0.045	0.055	0.066	0.070	0.079	0.100
1993	0.017	0.037	0.051	0.058	0.066	0.071	0.100
1994	0.020	0.036	0.058	0.062	0.070	0.076	0.100
1995	0.025	0.047	0.059	0.066	0.071	0.082	0.100
1996	0.019	0.038	0.051	0.058	0.061	0.071	0.100
1997	0.022	0.033	0.052	0.062	0.069	0.073	0.100
1998	0.024	0.040	0.055	0.061	0.064	0.067	0.100
1999	0.025	0.042	0.056	0.065	0.070	0.073	0.100
2000	0.025	0.037	0.056	0.066	0.071	0.074	0.100
2001	0.023	0.042	0.059	0.067	0.075	0.079	0.100
2002	0.028	0.045	0.057	0.069	0.075	0.079	0.100
2003	0.024	0.044	0.059	0.067	0.079	0.084	0.100
2004	0.020	0.040	0.056	0.066	0.072	0.082	0.100
2005	0.023	0.037	0.055	0.068	0.074	0.075	0.100
2006	0.031	0.042	0.056	0.068	0.073	0.078	0.100
2007	0.028	0.054	0.071	0.074	0.085	0.086	0.100
2008	0.025	0.043	0.066	0.074	0.075	0.083	0.100
2009	0.020	0.041	0.065	0.075	0.079	0.083	0.100
2010	0.026	0.046	0.061	0.075	0.082	0.084	0.100
2011	0.024	0.045	0.064	0.073	0.077	0.077	0.100
2012	0.031	0.056	0.065	0.078	0.083	0.086	0.100

Table 7.4.1b. Sardine in VIIIc and IXa: Mean weights-at-age (kg) in the stock. Weights-at-age 1978-1989 are fixed and equal to those in 1990.

Year	Age1	Age2	Age3	Age4	Age5	Age6+
1990	0.015	0.038	0.050	0.064	0.067	0.100
1991	0.019	0.042	0.050	0.064	0.071	0.100
1992	0.027	0.036	0.050	0.062	0.069	0.100
1993	0.022	0.045	0.057	0.064	0.073	0.100
1994	0.031	0.040	0.049	0.060	0.067	0.100
1995	0.029	0.050	0.062	0.072	0.079	0.100
1996	0.021	0.042	0.050	0.057	0.065	0.077
1997	0.024	0.032	0.052	0.059	0.064	0.072
1998	0.029	0.037	0.048	0.054	0.059	0.066
1999	0.024	0.040	0.052	0.059	0.067	0.073
2000	0.017	0.043	0.056	0.061	0.067	0.067
2001	0.021	0.041	0.060	0.071	0.072	0.074
2002	0.024	0.040	0.055	0.068	0.074	0.074
2003	0.019	0.043	0.053	0.065	0.070	0.076
2004	0.020	0.045	0.061	0.069	0.076	0.100
2005	0.019	0.045	0.059	0.068	0.073	0.079
2006	0.030	0.042	0.060	0.068	0.068	0.075
2007	0.039	0.054	0.062	0.070	0.076	0.077
2008	0.017	0.052	0.065	0.070	0.080	0.087
2009	0.020	0.053	0.060	0.065	0.069	0.076
2010	0.018	0.042	0.058	0.064	0.064	0.071
2011	0.026	0.048	0.058	0.065	0.066	0.067
2012	0.026	0.048	0.058	0.065	0.066	0.067

Table 7.5.1.1. Sardine in VIIIc and IXa: Parameters and asymptotic standard deviations estimated in the final assessment model.

Parameter	Phase	Min	Max	Initial value	Final Value	Std Dev
SR_LN(R0)	1	1	12	8.9	9.37	0.057
Main_RecrDev_1978	_	_	_	_	0.69	0.144
Main_RecrDev_1979	_	_	_	_	0.83	0.142
Main_RecrDev_1980	_	_	_	_	0.97	0.136
Main_RecrDev_1981	_	_	_	_	0.50	0.167
Main_RecrDev_1982	_	_	_	_	-0.08	0.226
Main_RecrDev_1983	_	_	_	_	1.43	0.108
Main_RecrDev_1984	_	_	_	_	0.27	0.182
Main_RecrDev_1985	_	_	_	_	0.21	0.176
Main_RecrDev_1986	_	_	_	_	0.02	0.184
Main_RecrDev_1987	_	_	_	_	0.74	0.126
Main_RecrDev_1988	_	_	_	_	0.15	0.159
Main_RecrDev_1989	_	_	_	_	0.11	0.158
Main_RecrDev_1990	_	_	_	_	0.14	0.154
Main_RecrDev_1991	_	_	_	_	1.15	0.089
Main_RecrDev_1992	_	_	_	_	0.81	0.097
Main_RecrDev_1993	_	_	_	_	0.00	0.131
Main_RecrDev_1994	_	_	_	_	-0.15	0.123
Main_RecrDev_1995	_	_	_	_	-0.47	0.124
Main_RecrDev_1996	_	_	_	_	-0.03	0.098
Main_RecrDev_1997	_	_	_	_	-0.55	0.121
Main_RecrDev_1998	_	_	_	_	-0.27	0.107
Main_RecrDev_1999	_	_	_	_	-0.47	0.122
Main_RecrDev_2000	_	_	_	_	0.66	0.079
Main_RecrDev_2001	_	_	_	_	0.14	0.099
Main_RecrDev_2002	_	_	_	_	-0.46	0.127
Main_RecrDev_2003	_	_	_	_	-0.74	0.154
Main_RecrDev_2004	_	_	_	_	0.75	0.068
Main_RecrDev_2005	_	_	_	_	-0.27	0.101
Main_RecrDev_2006	_	_	_	_	-1.37	0.156
Main_RecrDev_2007	_	_	_	_	-0.88	0.118
Main_RecrDev_2008	_	_	_	_	-0.64	0.108
Main_RecrDev_2009	_	_	_	_	-0.41	0.110
Main_RecrDev_2010	_	_	_	_	-1.08	0.158
Main_RecrDev_2011	_	_	_	_	-0.99	0.209
Main_RecrDev_2012	_	_	_	_	-0.71	0.213
InitF_1purse_seine	1	0	2	0.3	0.37	0.065
Q_base_3_DEPM_survey	1	-7	5	0	0.03	0.164
AgeSel_1P_2_purse_seine	2	-5	5	0.9	1.06	0.088
AgeSel_1P_3_purse_seine	2	-5	5	0.4	0.63	0.086
AgeSel_1P_4_purse_seine	2	-5	5	0.1	0.37	0.092
AgeSel_1P_7_purse_seine	2	-5	5	-0.5	-1.09	0.240
AgeSel_2P_3_Acoustic_survey	2	-5	9	-0.3	-0.26	0.090

Table 7.5.1.1. (cont.) Parameters and asymptotic standard deviations estimated in the final assessment model.

Parameter	Phase	Min	Max	Initial value	Final Value	Std Dev
AgeSel_2P_7_Acoustic_survey	2	-5	9	-0.8	-0.74	0.271
AgeSel_1P_2_purse_seine_BLK1delta_1978	2	-5	5	0.9	0.66	0.235
AgeSel_1P_3_purse_seine_BLK1delta_1978	2	-5	5	0.4	0.06	0.226
AgeSel_1P_4_purse_seine_BLK1delta_1978	2	-5	5	0.1	-0.58	0.257
AgeSel_1P_7_purse_seine_BLK1delta_1978	2	-5	5	-0.5	0.92	0.544
AgeSel_1P_2_purse_seine_DEVrwalk_1978	_	_	_	_	0.00	0.100
AgeSel_1P_2_purse_seine_DEVrwalk_1979	_	_	_	_	-0.02	0.097
AgeSel_1P_2_purse_seine_DEVrwalk_1980	_	_	_	_	-0.04	0.096
AgeSel_1P_2_purse_seine_DEVrwalk_1981	_	_	_	_	-0.05	0.096
AgeSel_1P_2_purse_seine_DEVrwalk_1982	_	_	_	_	-0.01	0.095
AgeSel_1P_2_purse_seine_DEVrwalk_1983	_	_	_	_	-0.03	0.095
AgeSel_1P_2_purse_seine_DEVrwalk_1984	_	_	_	_	-0.04	0.095
AgeSel_1P_2_purse_seine_DEVrwalk_1985	_	_	_	_	-0.07	0.096
AgeSel_1P_2_purse_seine_DEVrwalk_1986	_	_	_	_	-0.07	0.096
AgeSel_1P_2_purse_seine_DEVrwalk_1987	_	_	_	_	-0.07	0.096
AgeSel_1P_2_purse_seine_DEVrwalk_1988	_	_	_	_	0.00	0.096
AgeSel_1P_2_purse_seine_DEVrwalk_1989	_	_	_	_	0.02	0.097
AgeSel_1P_2_purse_seine_DEVrwalk_1990	_	_	_	_	0.01	0.098
AgeSel_1P_3_purse_seine_DEVrwalk_1978	_	_	_	_	0.00	0.100
AgeSel_1P_3_purse_seine_DEVrwalk_1979	_	_	_	_	0.05	0.096
AgeSel_1P_3_purse_seine_DEVrwalk_1980	_	_	_	_	0.02	0.095
AgeSel_1P_3_purse_seine_DEVrwalk_1981	_	_	_	_	0.02	0.094
AgeSel_1P_3_purse_seine_DEVrwalk_1982	_	_	_	_	0.03	0.094
AgeSel_1P_3_purse_seine_DEVrwalk_1983	_	_	_	_	-0.02	0.094
AgeSel_1P_3_purse_seine_DEVrwalk_1984	_	_	_	_	-0.02	0.093
AgeSel_1P_3_purse_seine_DEVrwalk_1985	_	_	_	_	0.01	0.094
AgeSel_1P_3_purse_seine_DEVrwalk_1986	_	_	_	_	-0.03	0.094
AgeSel_1P_3_purse_seine_DEVrwalk_1987	_	_	_	_	-0.03	0.094
AgeSel_1P_3_purse_seine_DEVrwalk_1988	_	_	_	_	0.02	0.095
AgeSel_1P_3_purse_seine_DEVrwalk_1989	_	_	_	_	0.03	0.096
AgeSel_1P_3_purse_seine_DEVrwalk_1990	_	_	_	_	0.01	0.097
AgeSel_1P_4_purse_seine_DEVrwalk_1978	_	_	_	_	0.00	0.100
AgeSel_1P_4_purse_seine_DEVrwalk_1979	_	_	_	_	0.04	0.098
AgeSel_1P_4_purse_seine_DEVrwalk_1980	_	_	_	_	0.03	0.097
AgeSel_1P_4_purse_seine_DEVrwalk_1981	_	_	_	_	0.04	0.097
AgeSel_1P_4_purse_seine_DEVrwalk_1982	_	_	_	_	0.05	0.096
AgeSel_1P_4_purse_seine_DEVrwalk_1983	_	_	_	_	0.02	0.095
AgeSel_1P_4_purse_seine_DEVrwalk_1984	_	_	_	_	0.00	0.095
AgeSel_1P_4_purse_seine_DEVrwalk_1985	_	_	_	_	0.02	0.095
AgeSel_1P_4_purse_seine_DEVrwalk_1986	_	_	_	_	0.01	0.095
AgeSel_1P_4_purse_seine_DEVrwalk_1987	_	_	_	_	0.02	0.095
AgeSel_1P_4_purse_seine_DEVrwalk_1988	_	_	_	_	0.05	0.095
AgeSel_1P_4_purse_seine_DEVrwalk_1989	_	_	_	_	0.05	0.096

Table 7.5.1.1. (cont.) Parameters and asymptotic standard deviations estimated in the final assessment model

Parameter	Phase	Min	Max	Initial value	Final Value	Std Dev
AgeSel_1P_4_purse_seine_DEVrwalk_1990	_	_	_	_	3.38E-02	0.096927
AgeSel_1P_7_purse_seine_DEVrwalk_1978	_	_	_	_	7.59E-07	0.1
AgeSel_1P_7_purse_seine_DEVrwalk_1979	_	_	_	_	0.0104584	0.099788
AgeSel_1P_7_purse_seine_DEVrwalk_1980	_	_	_	_	0.0150669	0.099748
AgeSel_1P_7_purse_seine_DEVrwalk_1981	_	_	_	_	2.09E-02	0.09974
AgeSel_1P_7_purse_seine_DEVrwalk_1982	_	_	_	_	2.37E-02	0.099683
AgeSel_1P_7_purse_seine_DEVrwalk_1983	_	_	_	_	0.0181659	0.099619
AgeSel_1P_7_purse_seine_DEVrwalk_1984	_	_	_	_	0.0106035	0.099591
AgeSel_1P_7_purse_seine_DEVrwalk_1985	_	_	_	_	0.00905156	0.099498
AgeSel_1P_7_purse_seine_DEVrwalk_1986	_	_	_	_	0.0107316	0.099339
AgeSel_1P_7_purse_seine_DEVrwalk_1987	_	_	_	_	1.05E-02	0.099089
AgeSel_1P_7_purse_seine_DEVrwalk_1988	_	_	_	_	0.0126835	0.099016
AgeSel_1P_7_purse_seine_DEVrwalk_1989	_	_	_	_	0.00752309	0.099087
AgeSel_1P_7_purse_seine_DEVrwalk_1990	_	_	_	_	0.00503744	0.09908

Table 7.5.1.2. Sardine in VIIIc and IXa: Fishing mortality-at-age estimated in the assessment. F(2-5) is the reference fishing mortality, corresponding to the average F of ages 2 to 5 years. NOTE: Fs for age 5 and consequentely mean F(2-5) were misreported in WGHANSA 2012 (see Section 7.9).

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6+
1978	0.048	0.267	0.530	0.431	0.431	0.431	0.364
1979	0.044	0.236	0.493	0.415	0.415	0.415	0.354
1980	0.042	0.218	0.465	0.402	0.402	0.402	0.348
1981	0.040	0.199	0.436	0.392	0.392	0.392	0.346
1982	0.036	0.177	0.402	0.378	0.378	0.378	0.343
1983	0.036	0.170	0.378	0.365	0.365	0.365	0.336
1984	0.037	0.168	0.365	0.353	0.353	0.353	0.329
1985	0.032	0.139	0.305	0.300	0.300	0.300	0.282
1986	0.038	0.154	0.326	0.325	0.325	0.325	0.309
1987	0.046	0.170	0.349	0.356	0.356	0.356	0.342
1988	0.042	0.158	0.331	0.356	0.356	0.356	0.347
1989	0.033	0.127	0.274	0.310	0.310	0.310	0.304
1990	0.039	0.150	0.328	0.384	0.384	0.384	0.378
1991	0.045	0.128	0.240	0.348	0.348	0.348	0.117
1992	0.033	0.093	0.175	0.254	0.254	0.254	0.085
1993	0.034	0.097	0.182	0.263	0.263	0.263	0.088
1994	0.029	0.083	0.156	0.225	0.225	0.225	0.076
1995	0.028	0.080	0.151	0.218	0.218	0.218	0.073
1996	0.037	0.105	0.198	0.286	0.286	0.286	0.096
1997	0.047	0.134	0.251	0.364	0.364	0.364	0.122
1998	0.053	0.154	0.288	0.417	0.417	0.417	0.140
1999	0.050	0.145	0.271	0.392	0.392	0.392	0.132
2000	0.044	0.127	0.238	0.344	0.344	0.344	0.116
2001	0.043	0.123	0.230	0.333	0.333	0.333	0.112
2002	0.036	0.104	0.194	0.281	0.281	0.281	0.095
2003	0.035	0.100	0.187	0.271	0.271	0.271	0.091
2004	0.038	0.109	0.205	0.297	0.297	0.297	0.100
2005	0.037	0.107	0.201	0.290	0.290	0.290	0.098
2006	0.032	0.092	0.172	0.249	0.249	0.249	0.084
2007	0.033	0.096	0.179	0.260	0.260	0.260	0.087
2008	0.049	0.141	0.264	0.382	0.382	0.382	0.129
2009	0.054	0.156	0.292	0.423	0.423	0.423	0.142
2010	0.069	0.198	0.371	0.537	0.537	0.537	0.181
2011	0.071	0.204	0.382	0.553	0.553	0.553	0.186
2012	0.048	0.137	0.257	0.371	0.371	0.371	0.125

Table 7.5.1.3. Sardine in VIIIc and IXa: Numbers -at-age (beggining of the year estimated in the assessment. Estimates of survivors in 2013 are also shown. Age 0 in 2013 is the geometric mean recruitment of the historical period.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6+
1978	23382	5087	2558	1182	647	354	455
1979	26854	10012	2363	1009	569	312	405
1980	30787	11552	4796	967	494	278	363
1981	19297	13267	5635	2019	479	245	328
1982	10774	8330	6593	2442	1011	240	294
1983	49046	4670	4232	2957	1239	513	277
1984	15414	21267	2390	1943	1521	638	410
1985	14463	6677	10901	1112	1011	792	551
1986	11927	6292	3523	5387	610	555	742
1987	24451	5158	3273	1704	2882	326	700
1988	13546	10497	2640	1547	884	1495	538
1989	13037	5834	5437	1270	803	459	1057
1990	13457	5665	3115	2770	690	436	827
1991	36980	5816	2958	1505	1398	348	640
1992	26458	15891	3103	1559	787	731	604
1993	11741	11508	8778	1746	896	452	831
1994	10068	5101	6336	4907	994	511	821
1995	7311	4395	2847	3634	2902	588	866
1996	11409	3194	2460	1641	2165	1728	946
1997	6788	4942	1743	1353	913	1204	1598
1998	8929	2911	2621	909	697	470	1668
1999	7289	3803	1514	1317	444	340	1303
2000	22573	3115	1996	774	659	222	1016
2001	13487	9705	1664	1055	406	346	787
2002	7390	5806	5206	886	560	216	705
2003	5609	3203	3175	2873	495	313	595
2004	24684	2434	1758	1765	1623	280	580
2005	8931	10677	1323	960	971	894	543
2006	2991	3866	5819	726	532	538	860
2007	4877	1302	2139	3283	419	307	896
2008	6166	2119	717	1198	1876	239	784
2009	7762	2638	1117	369	606	948	631
2010	3980	3304	1369	559	179	294	866
2011	4361	1669	1644	633	242	78	663
2012	5769	1825	826	752	270	103	441
2013	*11712	2472	965	428	384	138	341

*Not trusted value

Table 7.5.1.4. Sardine in VIIIc and IXa: Summary table of the final WGHANSA 2013 assessment. CVs, in %, are presented for SSB, recruitment and Apical F (maximum F-at-age by year); biomass and landings in thousand t, recruits in millions of individuals, F in year^{-1}. NOTE: Fs for age 5 and consequentely mean F(2-5) were misreported in WGHANSA 2012 (see Section 7.9).

Year	Biomass 1+	SSB	CV_{SSB}	Recruits	CV_R	F (2-5)	Apical F	$CV_{apicalF}$	Landings
1978	343	328	16	23382	14	0.46	0.53	16	146
1979	388	358	15	26854	14	0.43	0.49	16	157
1980	490	456	13	30787	14	0.42	0.47	14	195
1981	594	554	13	19297	17	0.40	0.44	14	217
1982	608	583	13	10774	23	0.38	0.40	14	207
1983	520	506	15	49046	11	0.37	0.38	15	184
1984	688	624	13	15414	18	0.36	0.37	15	206
1985	743	723	12	14463	18	0.30	0.30	11	208
1986	648	629	13	11927	19	0.33	0.33	14	187
1987	563	548	14	24451	13	0.35	0.36	16	178
1988	546	514	13	13546	17	0.35	0.36	17	162
1989	545	528	13	13037	17	0.30	0.31	18	141
1990	498	481	13	13457	17	0.37	0.38	17	149
1991	488	465	14	36980	10	0.32	0.35	16	133
1992	778	699	12	26458	11	0.23	0.25	15	130
1993	921	875	11	11741	14	0.24	0.26	15	142
1994	828	797	11	10068	13	0.21	0.23	13	137
1995	837	811	12	7311	14	0.20	0.22	13	125
1996	561	548	12	11409	11	0.26	0.29	13	117
1997	491	466	13	6788	13	0.34	0.36	13	116
1998	400	383	13	8929	12	0.38	0.42	14	109
1999	364	345	14	7289	14	0.36	0.39	14	94
2000	305	296	15	22573	10	0.32	0.34	15	86
2001	447	408	13	13487	12	0.31	0.33	15	102
2002	502	462	12	7390	14	0.26	0.28	15	100
2003	449	436	13	5609	17	0.25	0.27	14	98
2004	427	417	14	24684	9	0.27	0.30	14	98
2005	493	386	13	8931	12	0.27	0.29	15	97
2006	541	518	11	2991	17	0.23	0.25	14	87
2007	491	481	12	4877	13	0.24	0.26	12	96
2008	370	364	13	6166	13	0.35	0.38	14	101
2009	287	276	15	7762	14	0.39	0.42	17	87
2010	241	228	16	3980	18	0.50	0.54	18	90
2011	224	224	18	4361	24	0.51	0.55	22	80
2012	185	175	23	5769	24	0.34	0.37	26	55
2013	192								

Table 7.6.1 - Sardine in VIIIc and IXa: Input data for short term catch predictions. N-at-age for 2013. Input values of natural mortality (M), Maturity (Mat), proportion of F (PF), proportion of M (PM).

2013

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	5446	0.8	0	0	0	0.000	0.063	0.031
1	2472	0.5	0.8	0	0	0.026	0.180	0.056
2	965	0.4	1	0	0	0.048	0.337	0.065
3	428	0.3	1	0	0	0.058	0.487	0.078
4	384	0.3	1	0	0	0.065	0.487	0.083
5	138	0.3	1	0	0	0.066	0.487	0.086
6	341	0.3	1	0	0	0.067	0.164	0.100

2014

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	5446	0.8	0	0	0	0.000	0.063	0.027
1	.	0.5	0.8	0	0	0.023	0.180	0.049
2	.	0.4	1	0	0	0.046	0.337	0.063
3	.	0.3	1	0	0	0.058	0.487	0.075
4	.	0.3	1	0	0	0.065	0.487	0.081
5	.	0.3	1	0	0	0.065	0.487	0.082
6	.	0.3	1	0	0	0.068	0.164	0.100

Table 7.6.2 - Sardine in VIIIc and IXa: Output data for short term catch predictions.

2013				
Biomass	SSB	FMult	FBar	Landings
192	179	1	0.4494	71

2014	2015					
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
181	170	0	0.00	0	224	213
.	170	0.1	0.04	7	219	208
.	170	0.38	0.17	27	205	194
.	170	0.2	0.09	15	214	203
.	170	0.3	0.13	22	209	198
.	170	0.4	0.18	28	204	193
.	170	0.5	0.22	35	200	189
.	170	0.52	0.23	36	199	188
.	170	0.56	0.25	39	197	186
.	170	0.6	0.27	41	195	184
.	170	0.7	0.31	48	191	180
.	170	0.72	0.32	49	190	179
.	170	0.8	0.36	54	187	176
.	170	0.9	0.40	60	183	172
.	170	1	0.45	65	179	168
.	170	1.1	0.49	71	175	164
.	170	1.2	0.54	76	171	161
.	170	1.3	0.58	81	168	157
.	170	1.4	0.63	87	164	154
.	170	1.5	0.67	92	161	150
.	170	1.6	0.72	96	158	147
.	170	1.7	0.76	101	154	144
.	170	1.8	0.81	106	151	141
.	170	1.9	0.85	110	148	138
.	170	2	0.90	114	145	135

Input units are millions and kg - output in kilotonnes

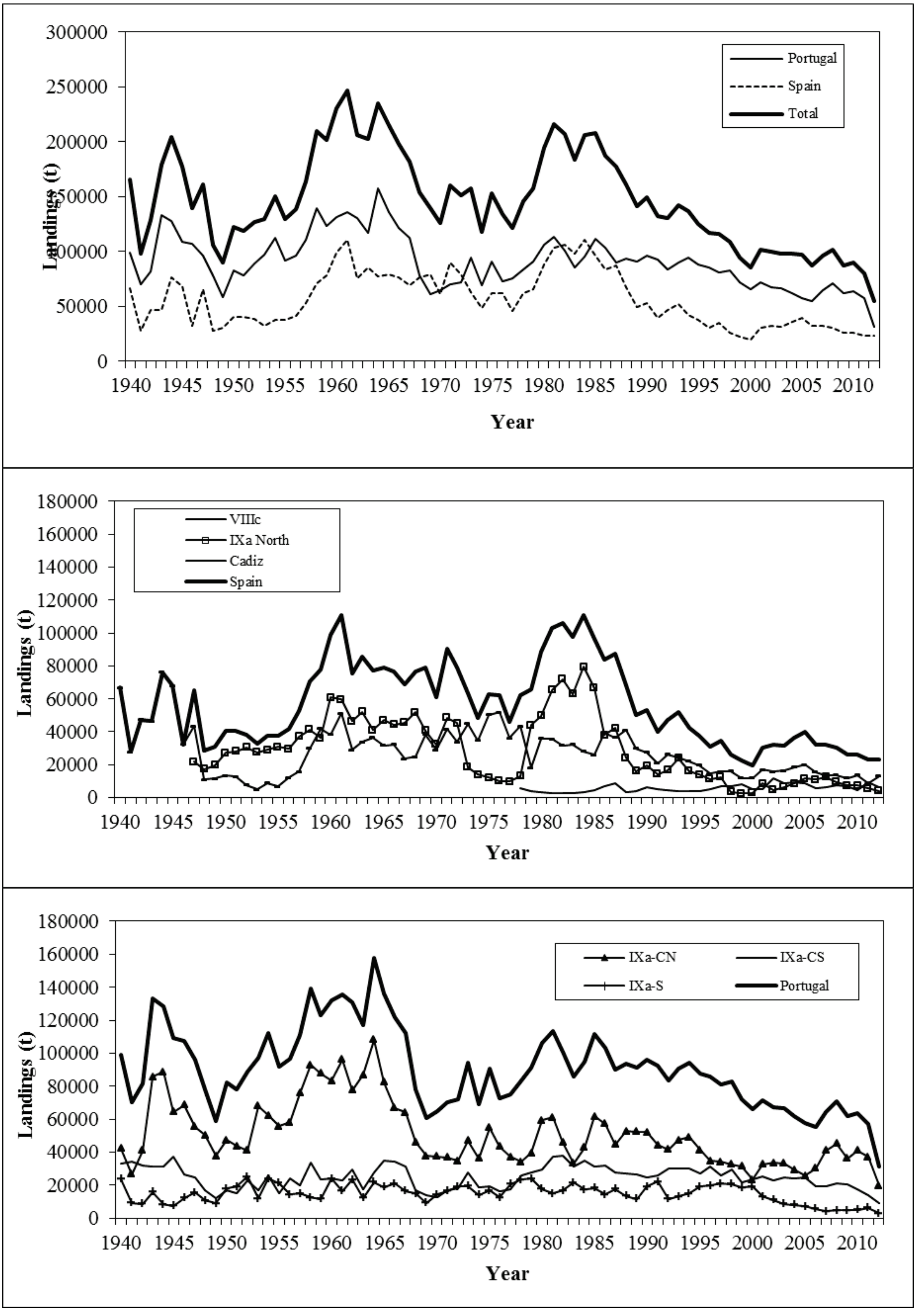


Figure 7.2.2.1: Sardine in VIIIc and IXa: Annual landings of sardine, by country (upper pannel) and by ICES subdivision and country.

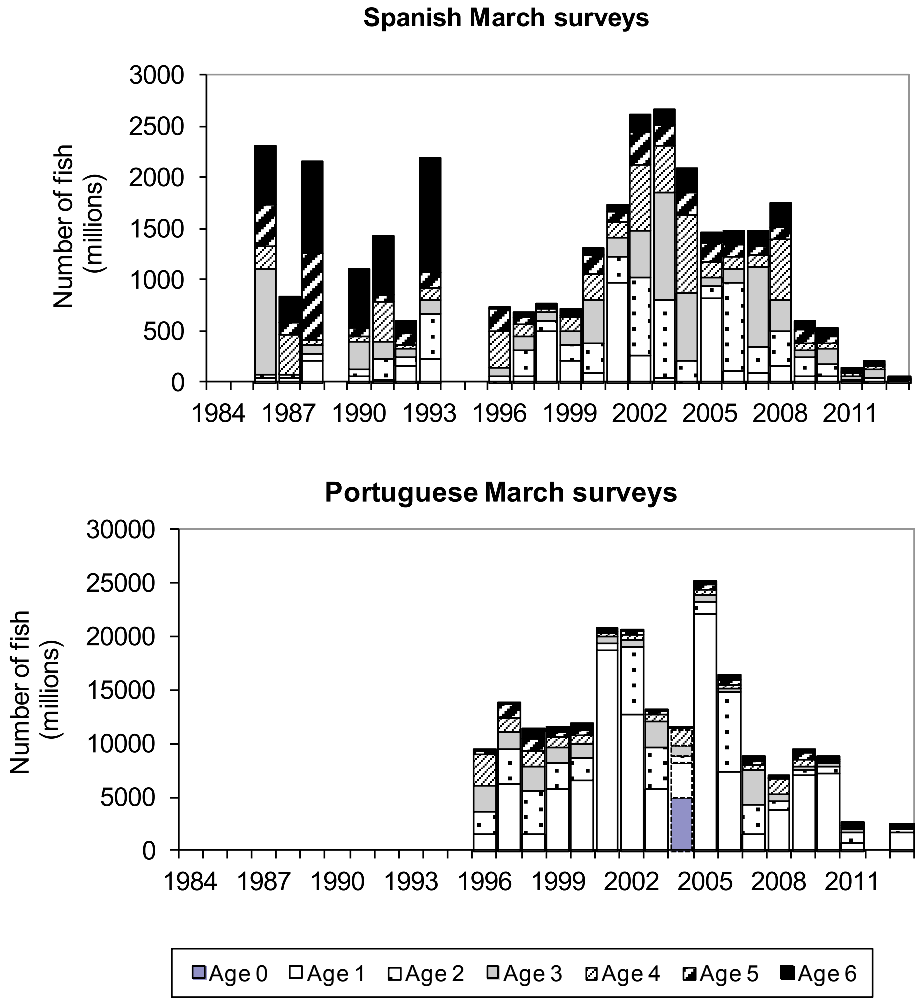


Figure 7.3.1: Sardine in VIIIc and IXa: Total abundance and age structure (numbers) of sardine estimated in the acoustic surveys. The Spanish March survey series covers area VIIIc and IXa-N (Galicia) and the Portuguese March surveys covers the Portuguese area and the Gulf of Cadiz (Subdivisions IXa-CN, IXa-CS, IXa-S-Algarve and IXa-S-Cadiz). Portuguese acoustic surveys in June 2004 was considered as indications of the population abundance and is not included in assessment. Estimates from Portuguese acoustic surveys are not available for 2012.

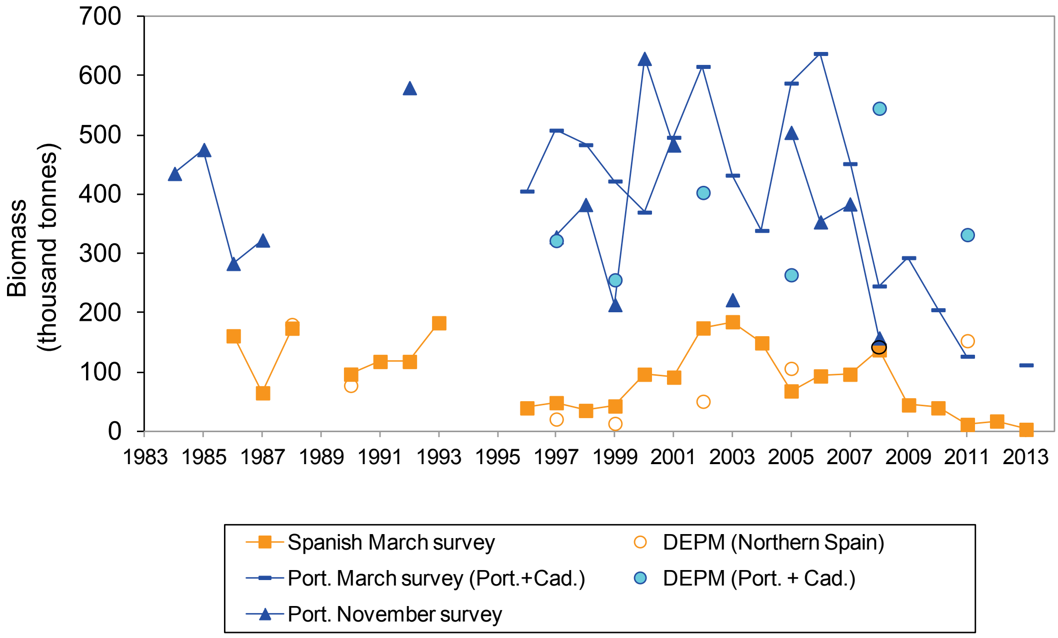


Figure 7.3.2: Sardine in VIIIc and IXa: Total sardine biomass (thousand tonnes) estimated in the different series of acoustic surveys and SSB estimates from the DEPM series covering the northern area and the west and southern area of the stock.

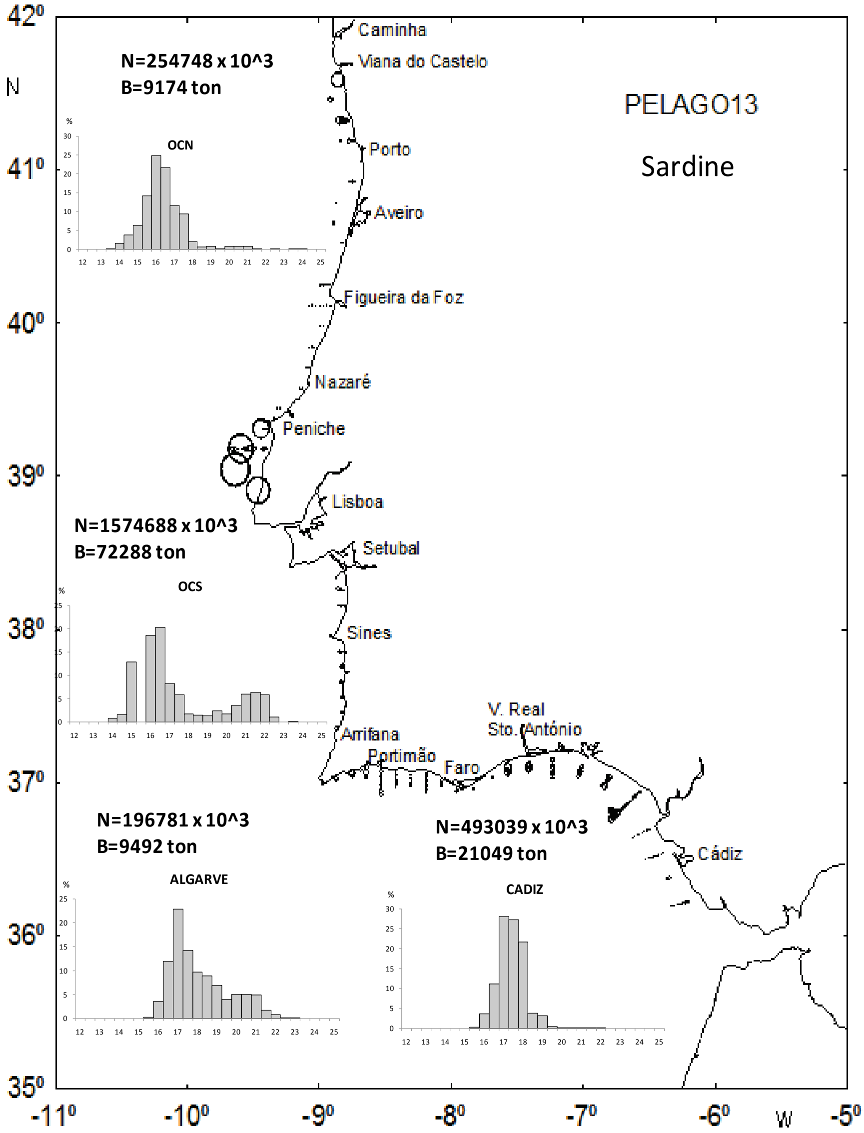


Figure 7.3.2.1.1: Sardine in VIIIc and IXa: Portuguese spring acoustic survey in 2013. Acoustic energy by nautical mile and abundance (in millions), biomass (in thousand tons) and length structure by area. Circle area is proportional to the acoustic energy (S_A m^2/nm^2).

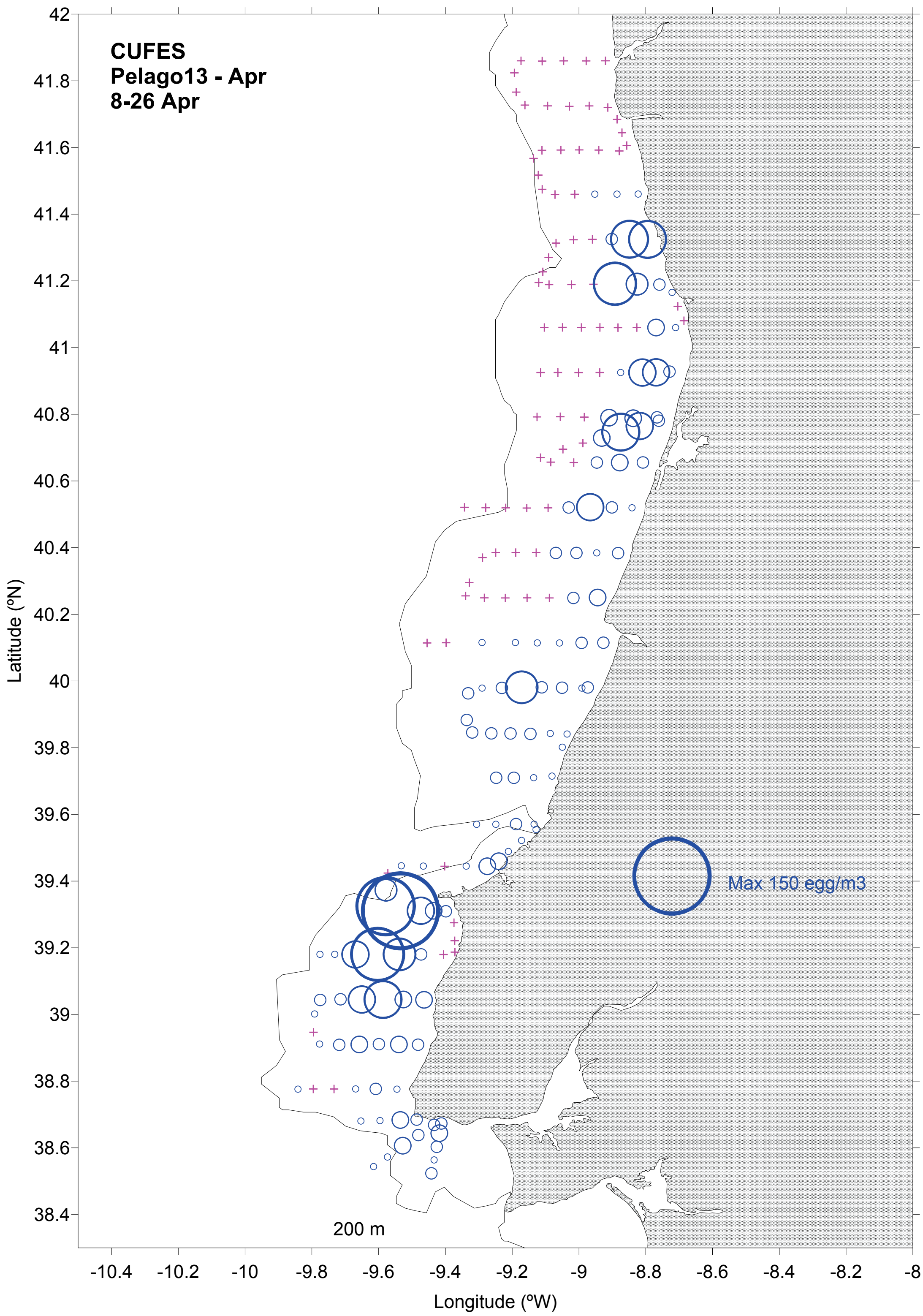
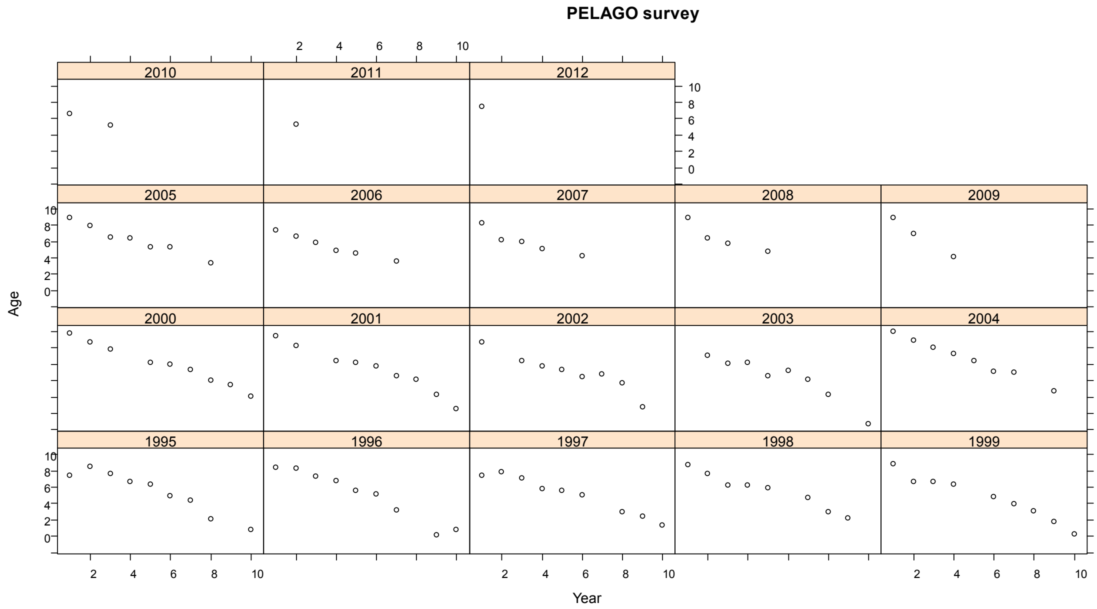
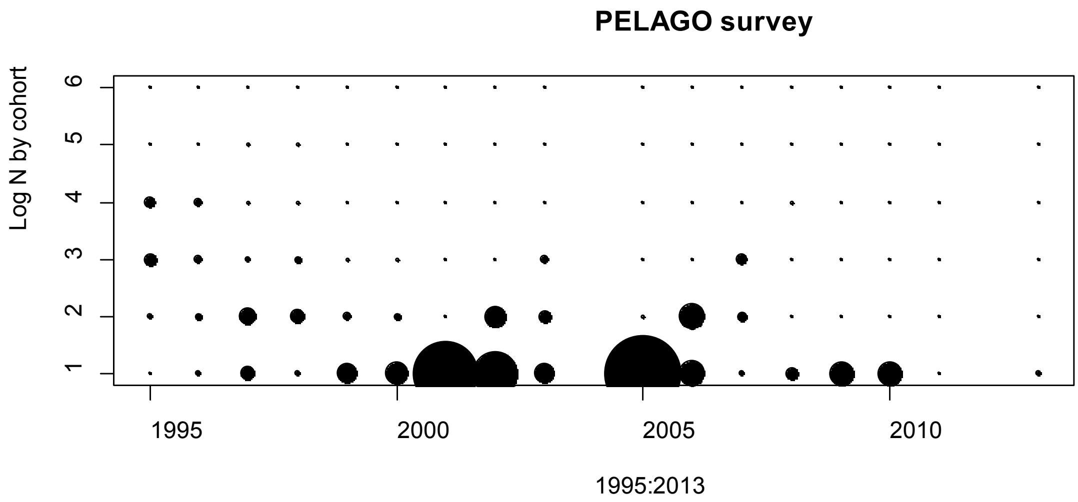
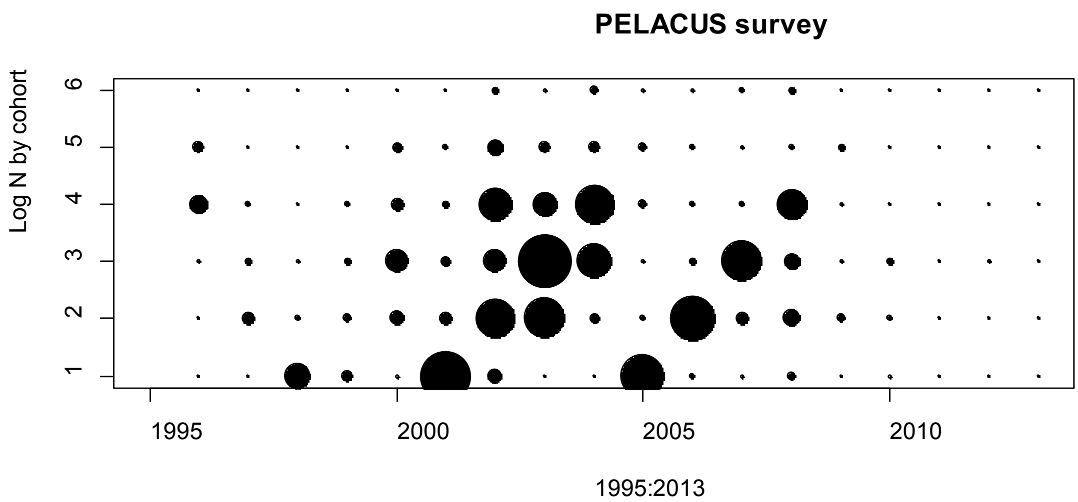


Figure 7.3.2.1.2: Sardine in VIIIc and IXa: Portuguese spring acoustic survey in 2013. Sardine egg presence (in situ observations) obtained by the CUFES+EDAS system in the northern area of the survey.



Figures 7.3.2.1.3: Sardine in VIIIc and IXa: Log-numbers at age by year-class (since 1995) in the Portuguese spring acoustic survey.





Figures 7.3.2.1.4: Sardine in VIIIc and IXa: Year-class signal (since 1995) in the Portuguese and Spanish spring acoustic surveys.

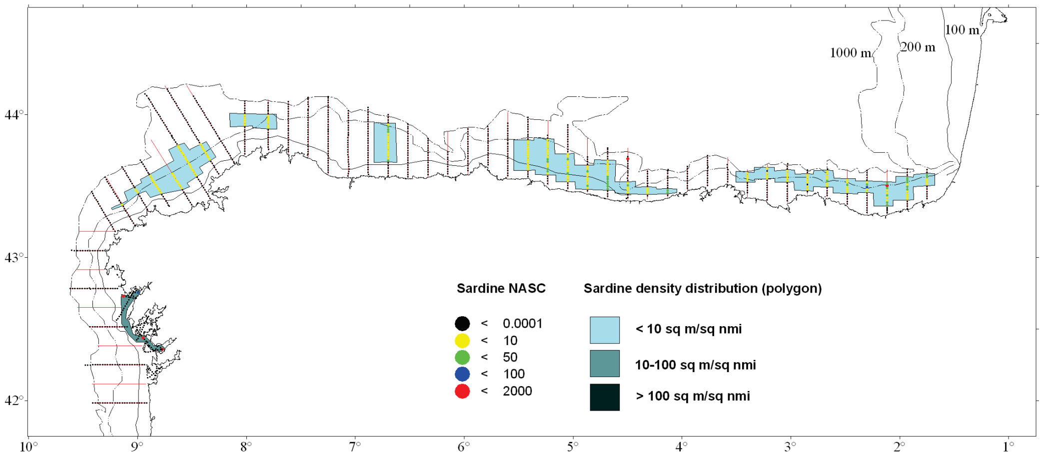


Figure 7.3.2.2.1: Sardine in VIIIc and IXa: Spatial distribution of energy allocated to sardine during the PELACUS0313 survey. Polygons are drawn to encompass the observed echoes, and polygon colour indicates integrated energy in m² within each polygon.

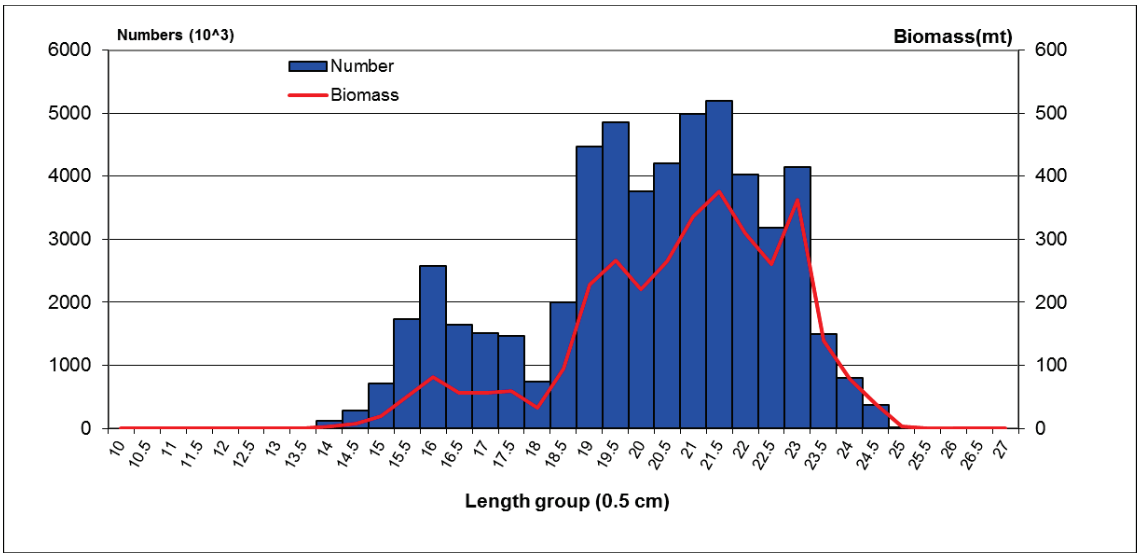
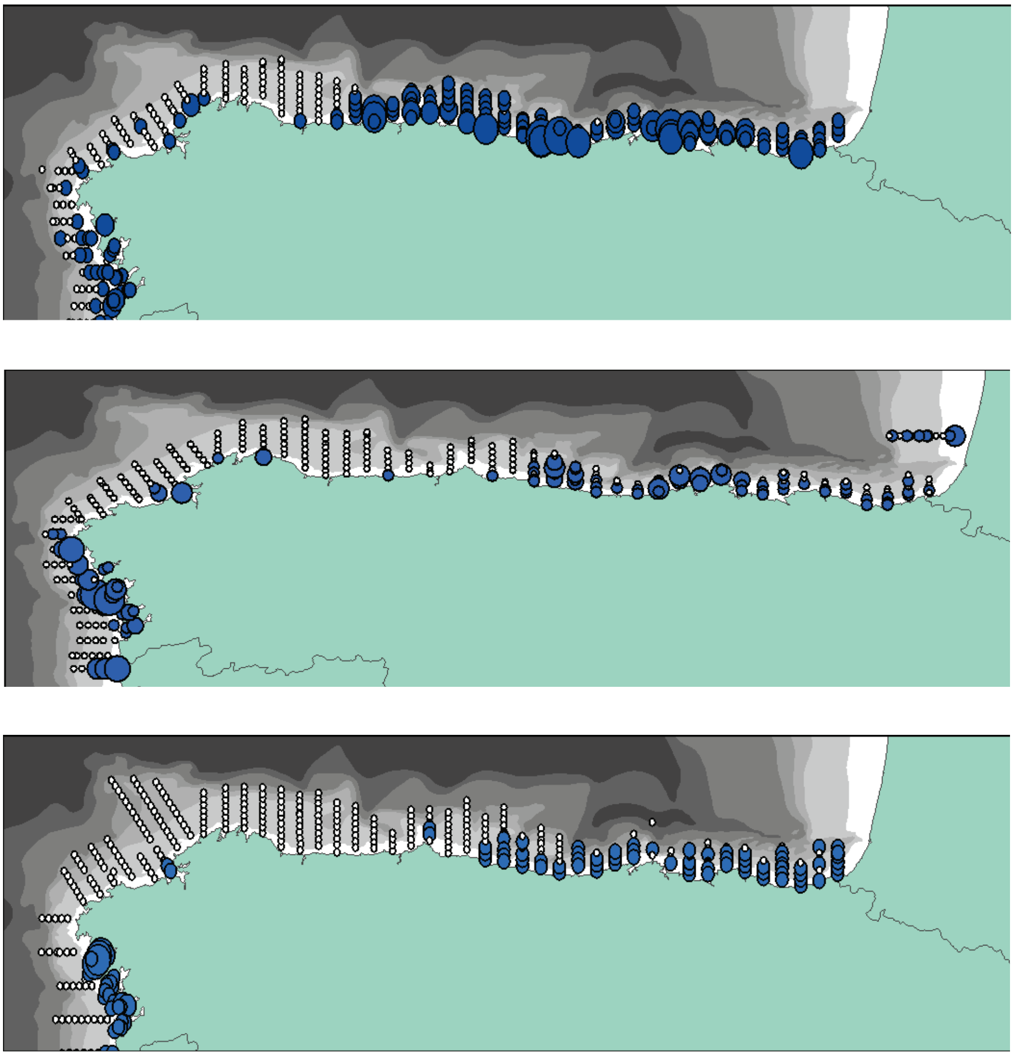


Figure 7.3.2.2.2: Sardine length distribution (cm) in numbers and biomass (tonnes) during the PELACUS0313 survey.

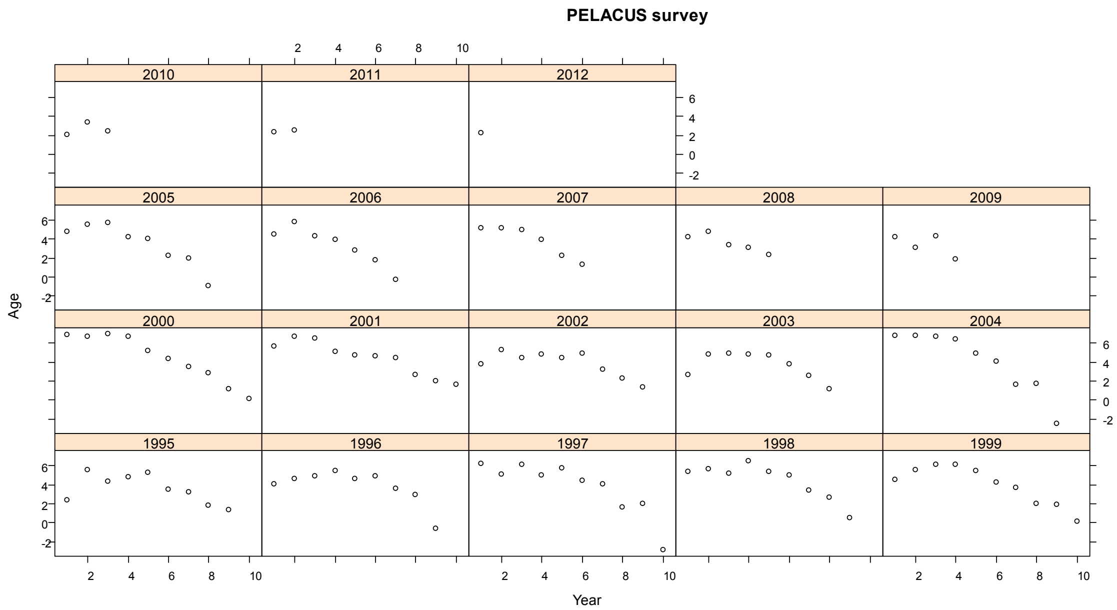


2011

2012

2013

Figure 7.3.2.2.3: Sardine in VIIIc and IXa: Total number of sardine eggs obtained during the PELACUS (2011-2013) surveys. Diameter of circles is proportional to egg abundance.



Figures 7.3.2.2.4: Sardine in VIIIc and IXa: Log-numbers at age by year-class (since 1995) in the Spanish spring acoustic survey.

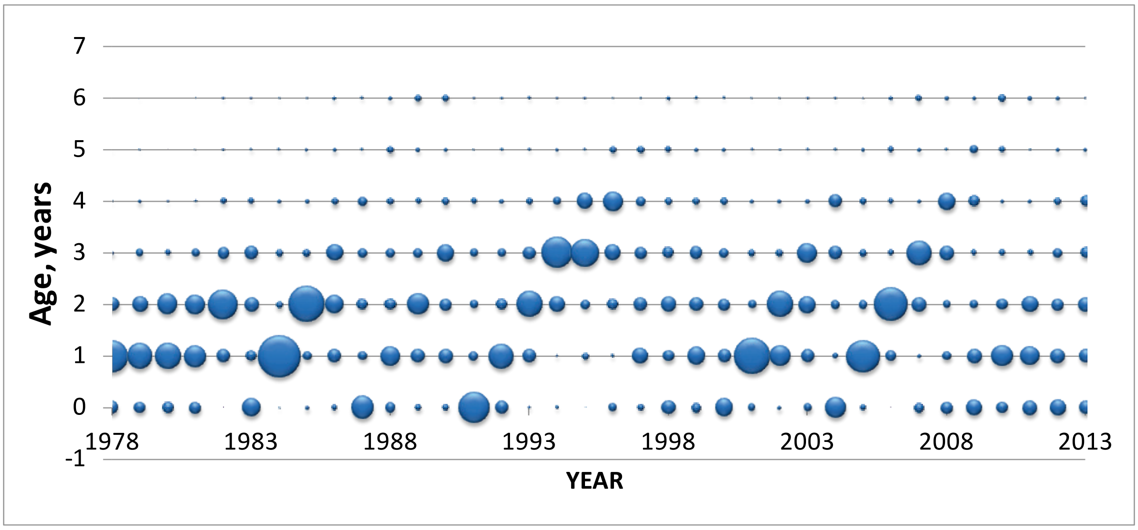


Figure 7.4.4.1. Sardine in VIIIc and IXa: Catches-at-age for 1978-2012.

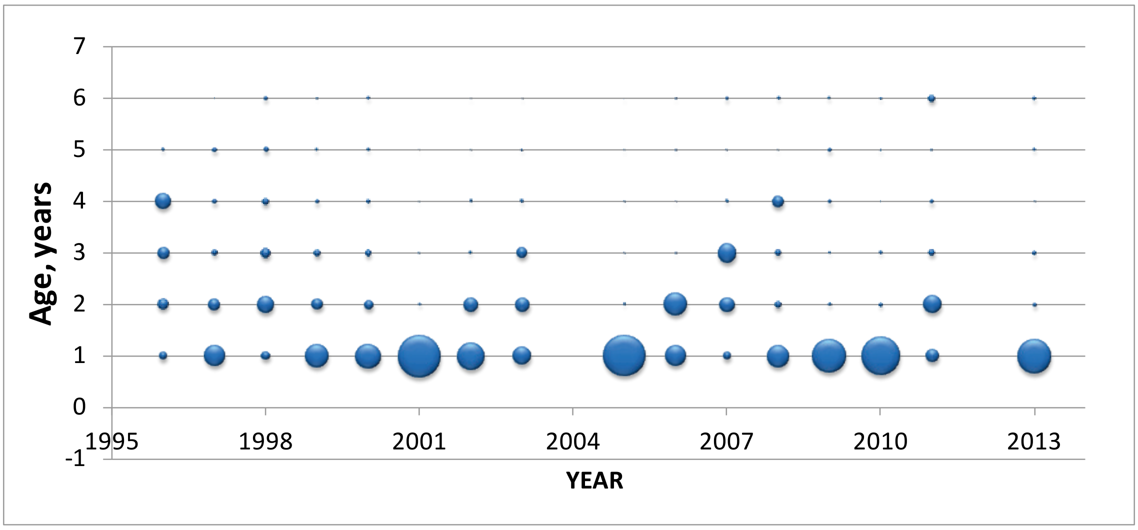


Figure 7.4.4.2. Sardine in VIIIc and IXa: Abundance-at-age in the joint Spanish-Portuguese spring acoustic survey 1996-2013.

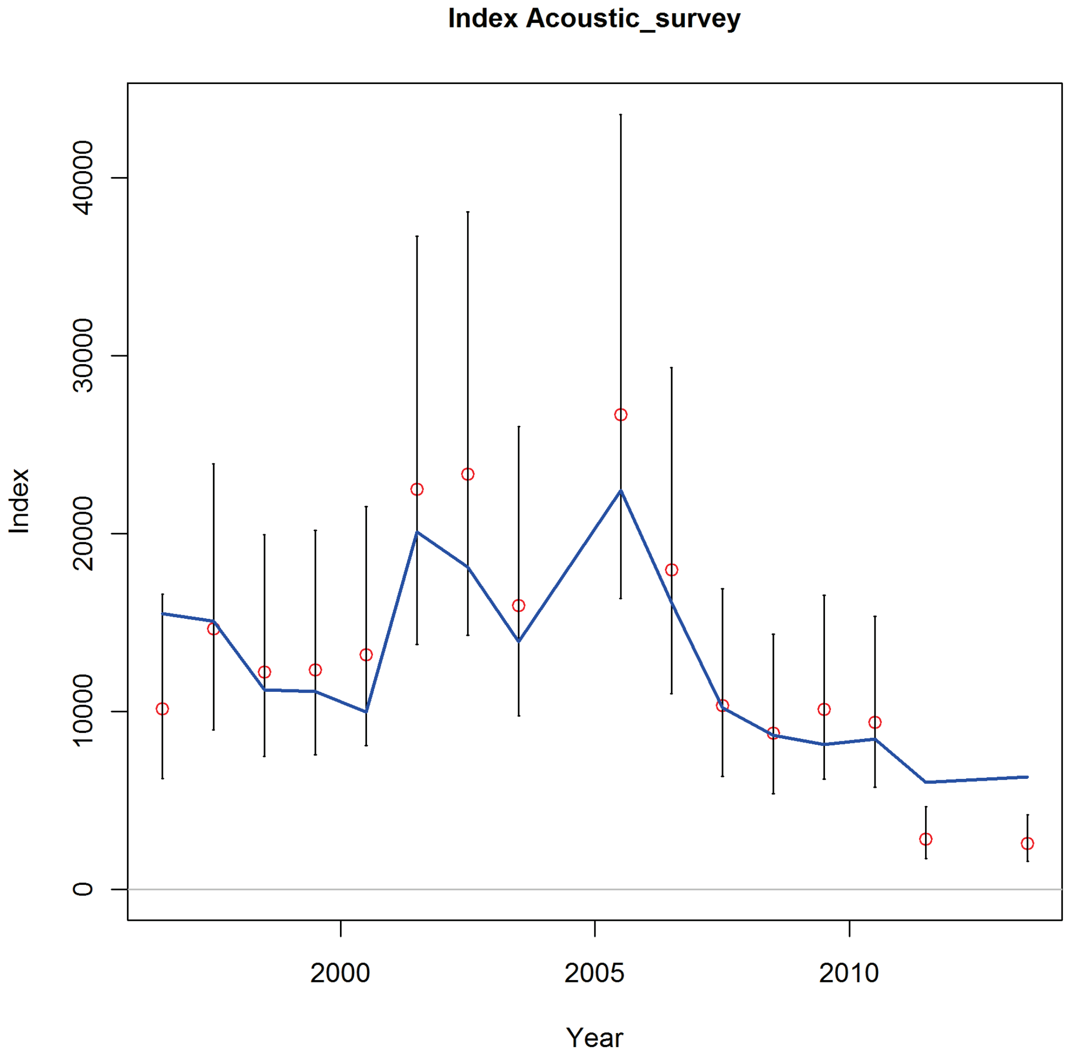


Figure 7.5.1.1. Sardine in VIIIc and IXa: Model fit to the acoustic survey series. The index is total abundance (in thousands of individuals). Bars are standard errors re-transformed from the log scale.

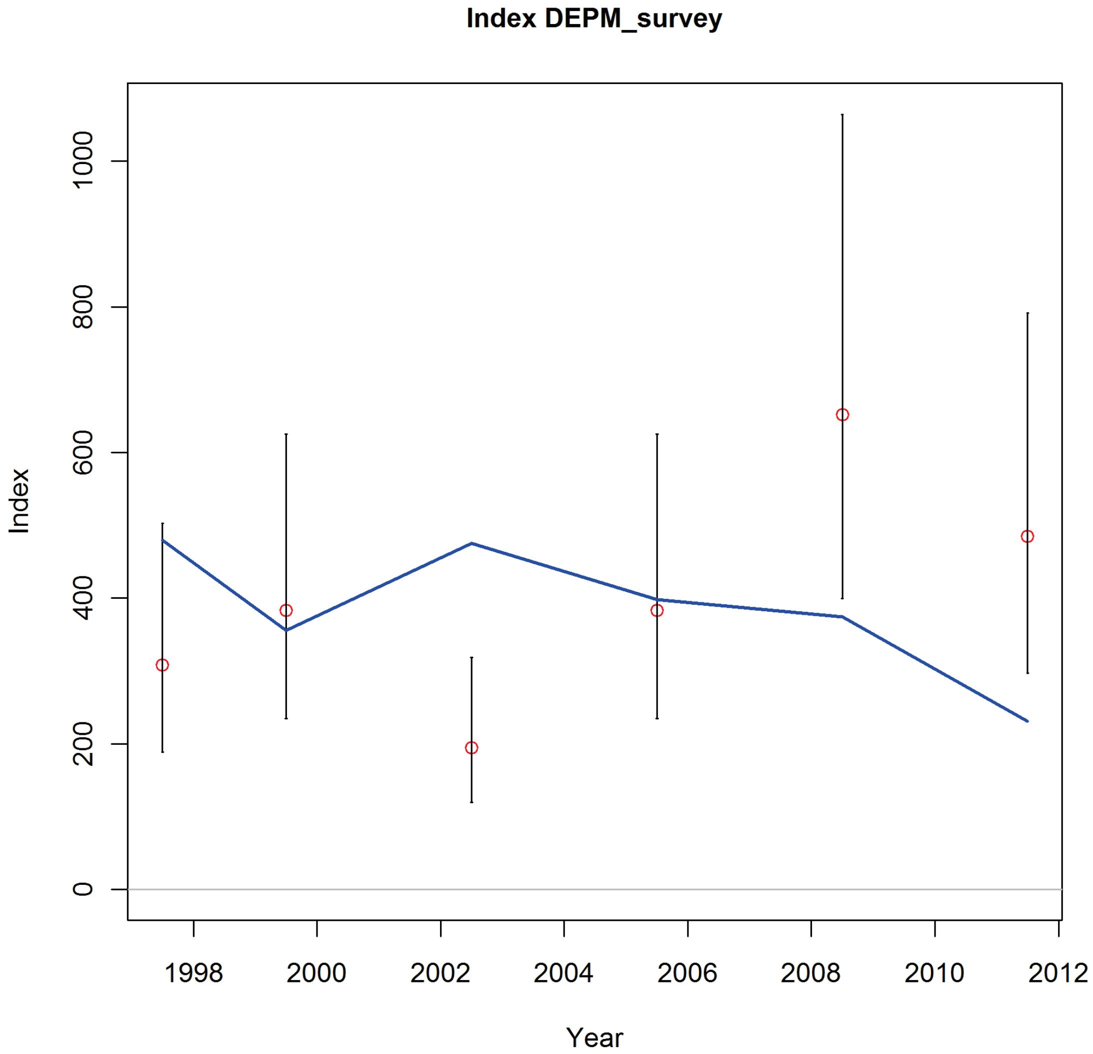


Figure 7.5.1.2: Sardine in VIIIc and IXa: Model fit to the DEPM survey series. The index is SSB (in thousand tons). Bars are standard errors re-transformed from the log scale.

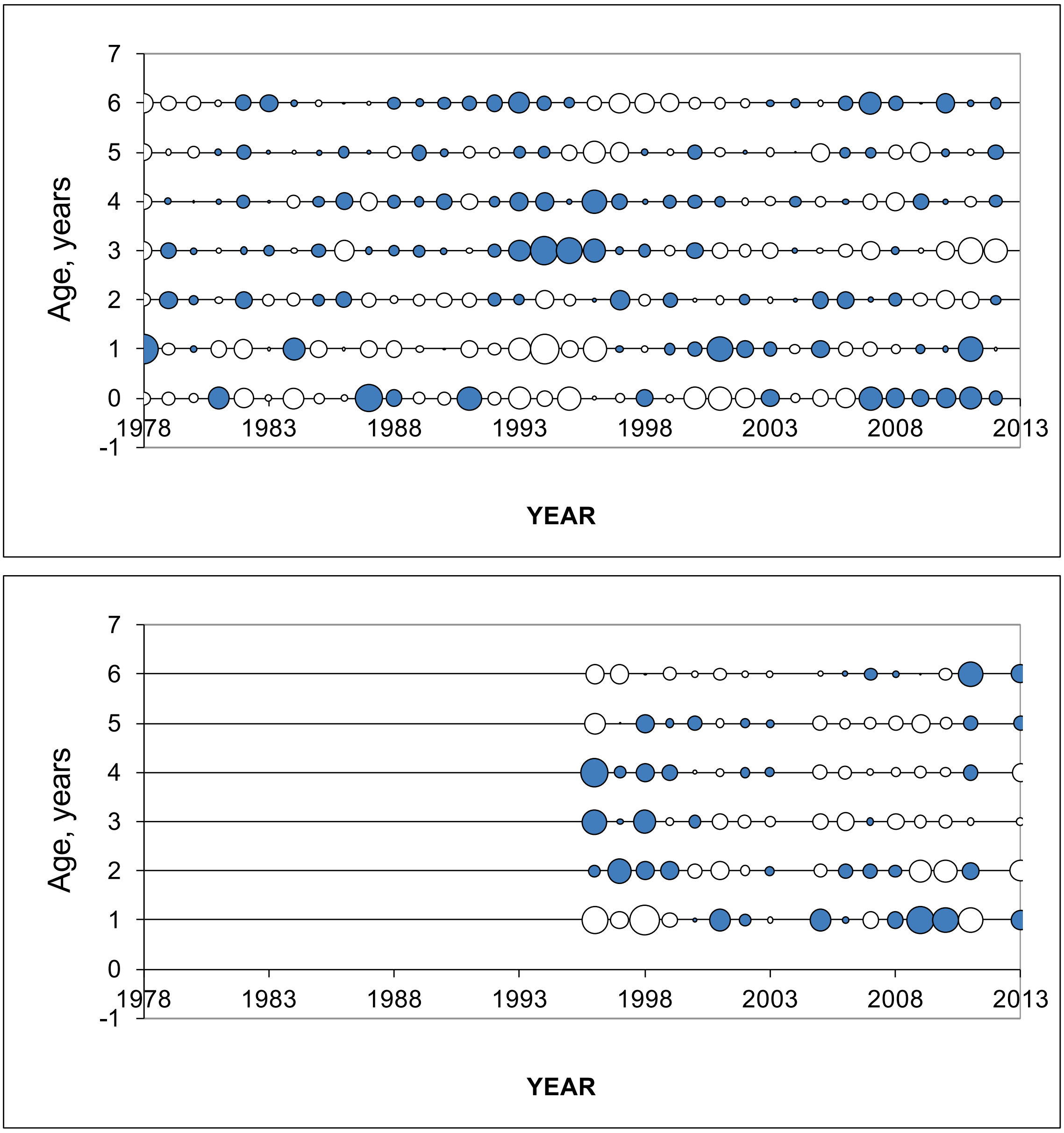
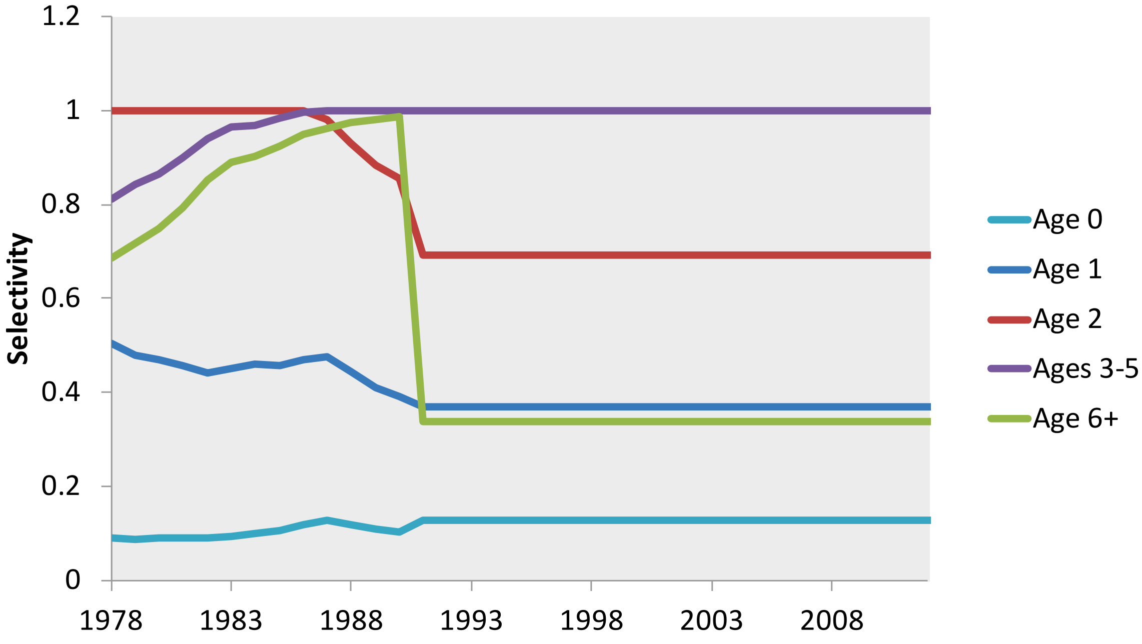


Figure 7.5.1.3. Sardine in VIIIc and IXa: Model residuals from the fit to the catch-at-age composition (a) and the acoustic survey age composition (b). Solid symbols correspond to positive residuals. Residuals are in the range [-2.9,3.1] for catch and in the range [-3.4, 2.9] for survey age compositions.



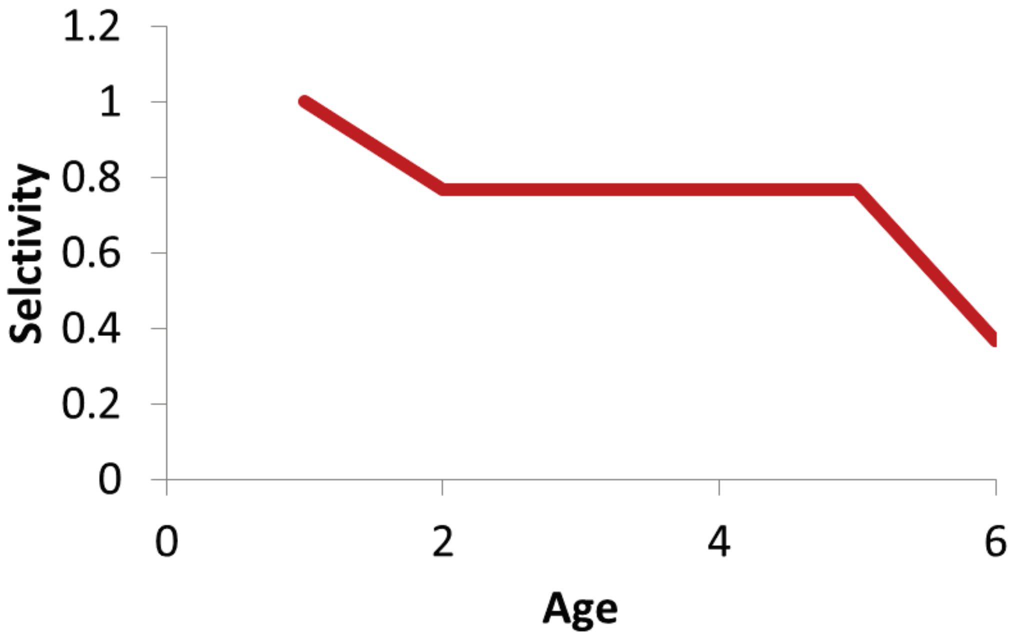


Figure 7.5.1.4. Sardine in VIIIc and IXa: Selectivity-at-age in the fishery (a) and in the acoustic survey (b).

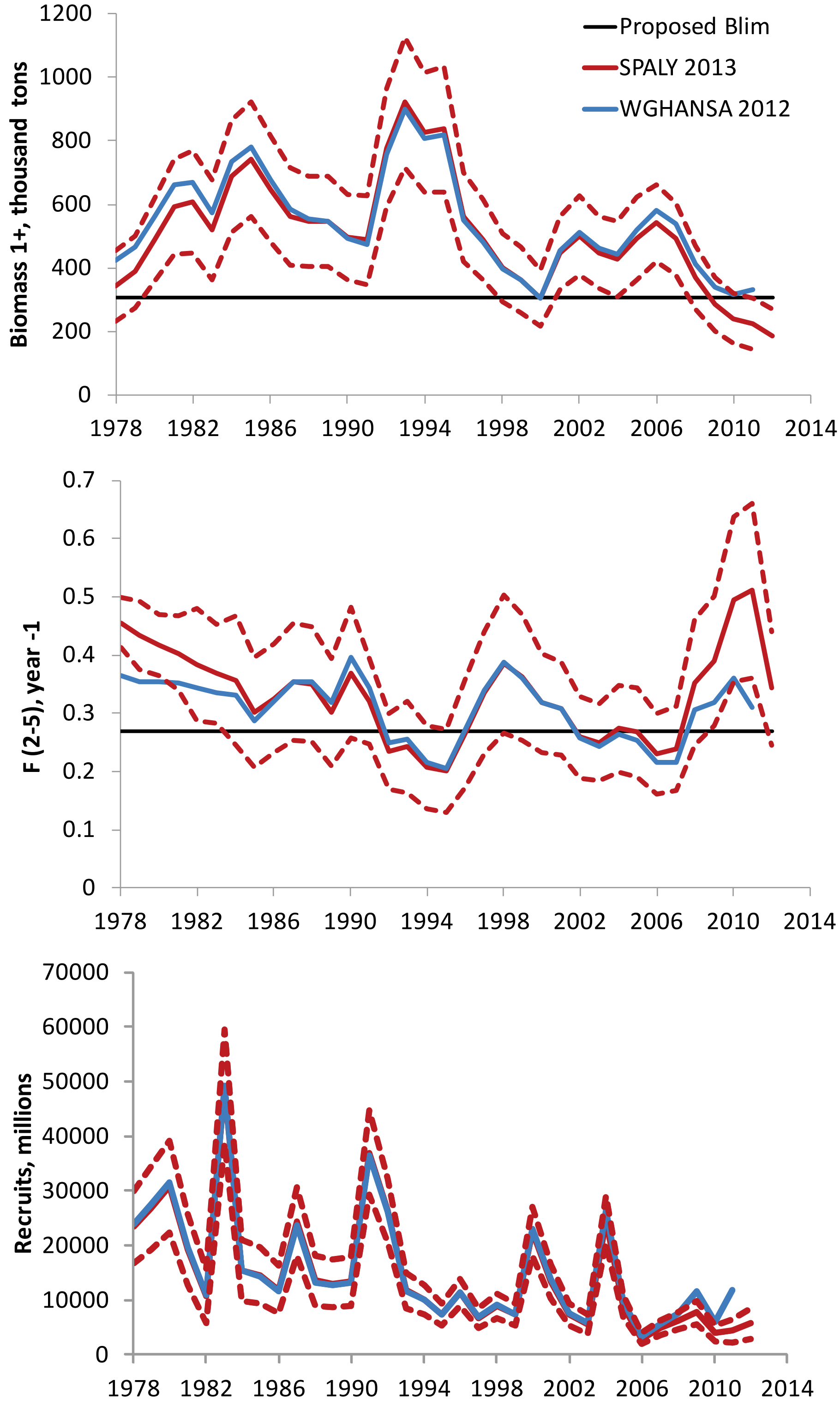


Figure 7.5.1.5. Sardine VIIIc and IXa: Historical B1+ (top), F (middle) and recruitment (bottom) trajectories in the period 1978 – 2011. The WKPELA 2012 assessment is shown for comparison.

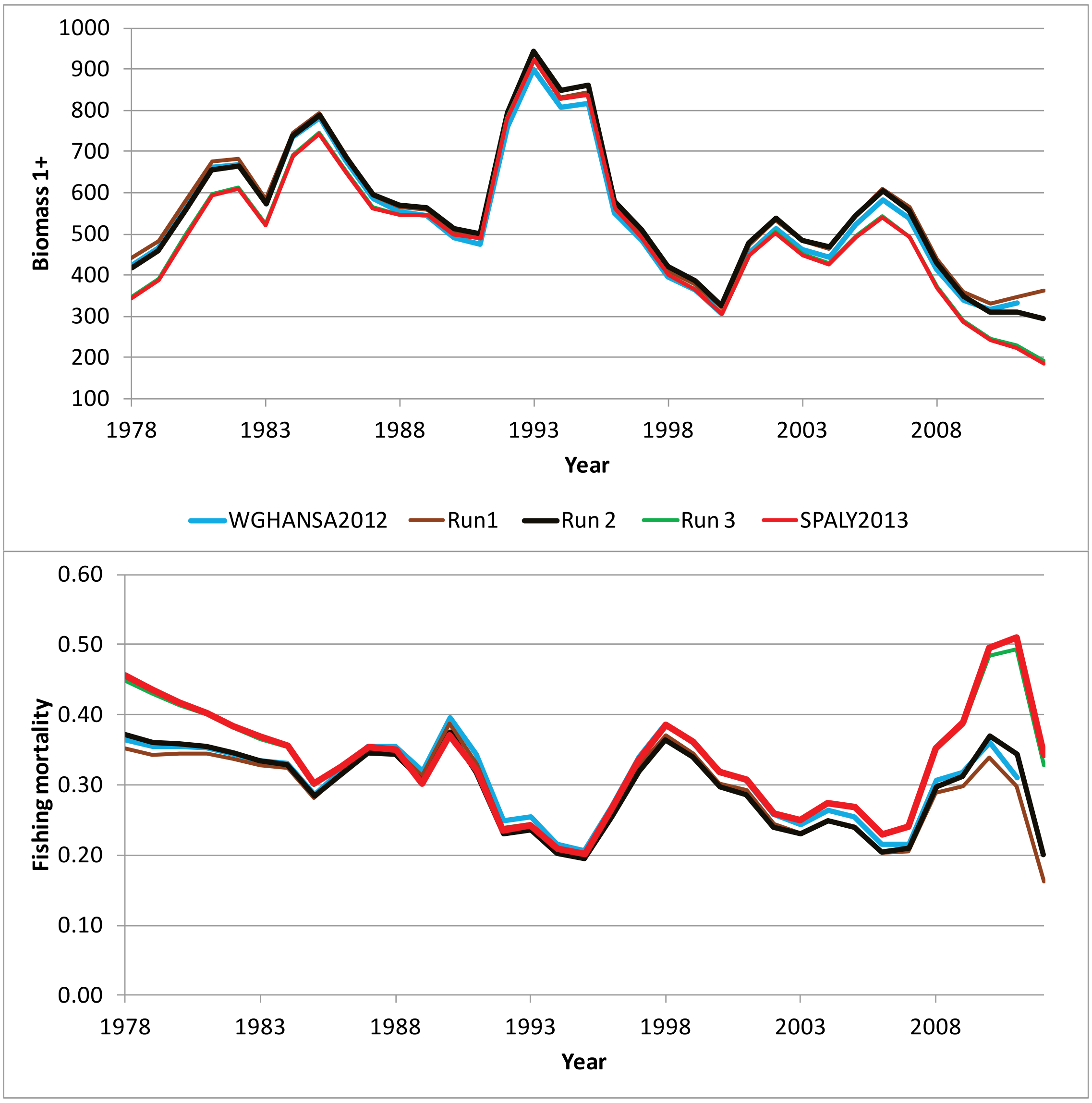


Figure 7.5.2. Sardine in VIIIc and IXa: Sensitivity of the assessment to the use of the 2013 acoustic survey. Run 1: no 2013 acoustic survey, Run 2: 50% CV in survey, Run : biomass in the Spanish =15 thousand t.

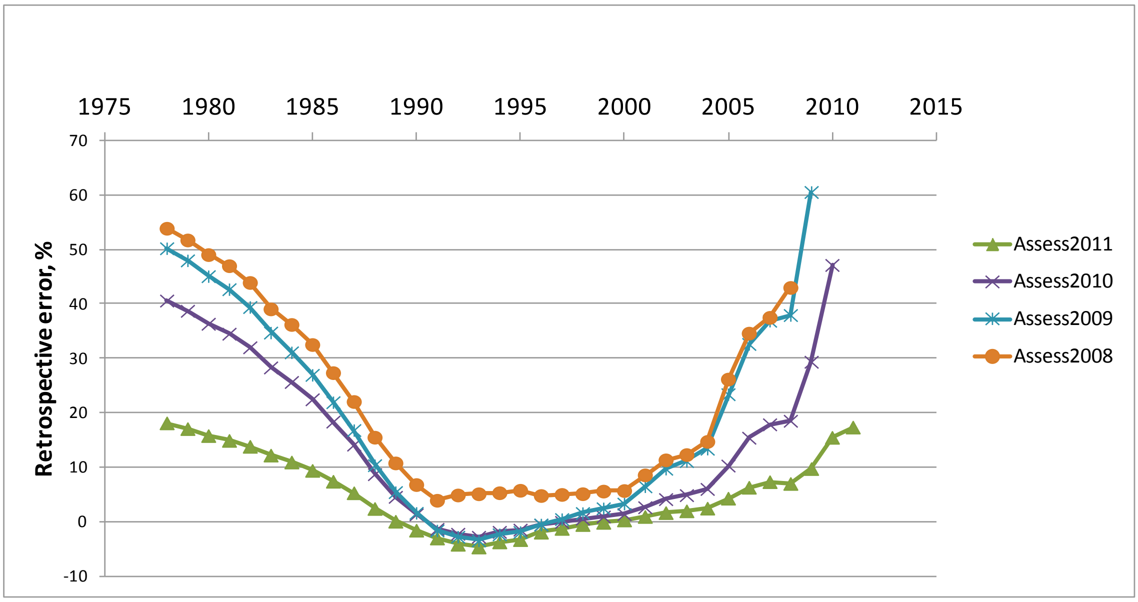


Figure 7.5.3.1 Retrospective error for the biomass in the assessment. Values calculated as (By,Asses y-By,Assess 2013)/ By,Assess 2013.The Assess 2012 results are not comparable because the model structure was different from other years due to the lack of a survey in the interim year.

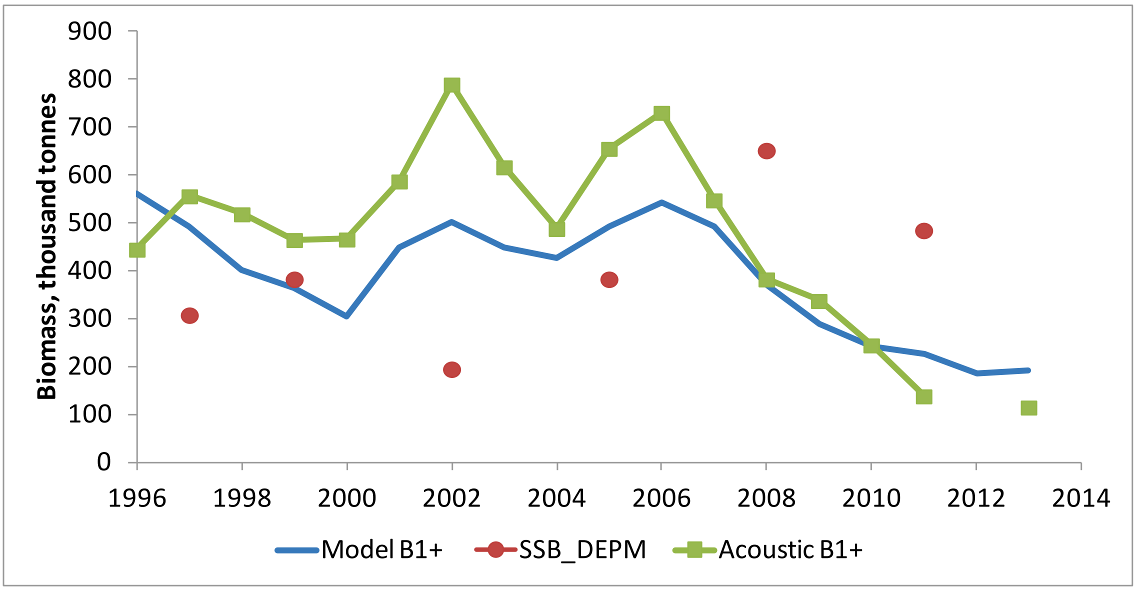


Figure 7.5.3.2. Sardine VIIIc and IXa: Biomass estimates by the acoustic survey, the DEPM survey and the assessment model in 1996 – 2013.

8 Southern Horse Mackerel (Division IXa

8.1 ACOM Advice Applicable to 2012, STECF advice and Political decisions

In 2012 ICES considered that in the absence of defined reference points, the state of this stock cannot be evaluated with regard to these. Catches decreased from the early 1960s but have been relatively stable since the early 1990s. Biomass has been stable during the assessment period. ICES further stated that the recent level of catches does not seem to be detrimental to the stock but wide confidence intervals indicate high uncertainty in the estimations. ICES therefore recommends that catches in 2013 should not exceed the present level of fishing mortality. This would imply landings of less than 26 000 t. ICES also recommended that the TAC for this stock should only apply to *Trachurus trachurus.*

The TAC finally accepted by the European Commission was of 30 800 ton.

8.2 The fishery in 2011

8.2.1 Quality of the fishery input data

Last year the assessment of southern horse mackerel was not updated due to inconsistent reporting of the Spanish catches to the WG. This year this problem has been solved (see section 1.4).

8.2.2 Fishing Fleets in 2012

Six fleets used to target on southern horse mackerel in division IXa. These fleets are considered defined by the gear type (bottom trawl, purse seine and artisanal) and country (Portugal and Spain). Portuguese bottom trawl fleet, Portuguese purse seine fleet and Spanish purse seine fleet show a similar exploitation pattern with a great presence of juveniles and lower abundance of adults. On the other hand the Portuguese artisanal fleet, and the Spanish bottom trawl and artisanal fleets show the opposite: a significant presence of adults and low presence of juveniles. The catch of Spanish artisanal fishery is negligible (<5%). Description of the Portuguese and Spanish fleets is available in Stock Annex.

8.2.3 Catches by fleet and area

Catch allocation between Subdivisions for this stock is described in the Stock Annex. The definition of the ICES Subdivisions was set in 1992 and some of the previous catch statistics came from an area that comprises more than one Subdivision. This is the case of the Galician coasts where the Subdivisions VIIIc West and Subdivision IXa North are located. Further work is necessary to collect the catches by port and to distribute them by Subdivision. At the moment it has been collected the required information for the period 1992–2012, and it is expected to go back in time during the next years.

The catch time series during the assessment period does not show a clear trend, with a peak reached in 1998 and a minimum in 2003 (**Table 8.2.3.1**). The relative contribution of each gear to the total catch is given in **Table 8.2.3.2**. In 2012 the relative contribution of each gear has changed due to there has been a significant decrease in landings for Spanish bottom trawl fleet and a significant increase for Portuguese purse-seine fleet landings. The different fleets targeting Southern horse mackerel are described in the Stock Annex.

In general Discards of southern horse mackerel are considered scarce. Spain and Portugal provided discards from 2011(**Table 8.2.3.3**). The Horse mackerel Spanish Discards are low, in particular in Subdivision IXa North. Spanish discards come from the bottom trawl fleet.

The Portuguese discards of horse mackerel are usually very low and not frequent. Discards have been estimated for 2005 for the bottom-trawl fleet targeting finfish as 61 tons. For other years, estimates were not obtained because the frequency of occurrence of discards was too low, and therefore estimates could be highly biased (see Prista et al., 2013WD in Annex).

8.2.4 Effort and catch per unit effort

No series of catch-per-unit-effort is currently available to be used for stock assessment.

8.2.5 Catches by length and catches at age

The procedure to estimate numbers at age in the catch is described in the Stock Annex.

In the time series of the catch in numbers at age, the 1994 year class showed high catches at ages 11 and 12 and the 1996 year class appears to be conspicuous at juvenile ages (0, 1 and 2) and reappearing again at ages 8 and 10. (Table 8.2.5.1, Figure 8.2.5.1). In general, catches are dominated by juveniles and young adults, although in recent years there is an increment of catch of older ages.

To know more in depth the exploitation history of the southern horse mackerel a series of catch in numbers at age by fishing fleet is provided (Table 8.2.5.2, Figure 8.2.5.2). Three fishing fleets are considered defined by the gear type (bottom trawl, purse seine and artisanal) and country (Portugal and Spain). The new time series starts in 1992 although it is expected to be extended back in time in the future.

The following fleets: Portuguese bottom trawl fleet, Portuguese purse seine fleet and Spanish purse seine fleet show a similar exploitation pattern with a great presence of juveniles and lower abundance of adults. On the other hand the Portuguese artisanal fleet, and the Spanish bottom trawl and artisanal fleets show the opposite: a significant presence of adults and low presence of juveniles. The catch of Spanish artisanal fishery is negligible.

8.2.6 Mean weight at age in the catch

Detailed information on the way to calculate mean weight and mean length at age values is included in the Stock Annex.

Table 8.2.6.1 and Table 8.2.6.2 show the mean weight at age in the catch, and the mean length at age in catch respectively from 1992 to 2012. The mean weight at age in the catch increased significantly in 2004 for the ages above 3 years old, being for some of these ages the highest of the historical series (Figure 8.2.6.1). Ages above 4 years old show a significant increase trend in mean weigh at age in the last 3-4 years. The mean length at age showed a smooth increase trend for those ages since 2002 with a decrease in 2005 and 2006 (Table 8.2.6.2).

8.3 Fishery independent information

In relation to the DEPM: The methods to obtain egg abundance estimates and adult parameters are under revision within ICES WGMEGS. Therefore, at present there are no reliable SSB estimates from the DEPM to be used in the assessment of the stock.

8.3.1 Bottom-trawl surveys

The Spanish survey from Subdivision IXa North and the Portuguese survey are treated as a single survey, although they are carried out with different vessels and slightly different bottom-trawl gears. Although in 2012 Portuguese survey was not carried out

The survey indices from these surveys are shown in Table 8.3.1.1. The catchability of these vessels (B/O Cornide de Saavedra and N/I Noruega) and fishing gears were compared for different fish species during project SESITS (Sanchez *et al.*, no date) and no significant differences were found for horse mackerel. Thus, the raw data (number per hour and age in each haul, including zeros) of the two data sets were merged and treated as a single data set in order to estimate a combined survey index. Due to there was not Portuguese survey in 2012, it could not be estimated the combined survey index for 2012.

The abundance data by age and year do not follow a Normal distribution, having a big proportion of zeros and a few extreme values. This is explained by the patchiness in the distribution of horse mackerel and by its characteristic of forming large shoals. Therefore, it is questionable whether a simple average of the number-per-hour, by age and year, is an adequate abundance index for tuning the stock assessment.

Table 8.3.1.2 shows the combined survey index (mean number per hour, by age and year) used in the assessment. There are two very clear features in this data set: a strong variability of age 0 and strong year-effects (some years with higher abundance of all ages than others). The first feature may be explained by the greater aggregation tendency of these small fish in dense shoals and by their typically pelagic behaviour which makes them less available to the bottom-trawl. The apparent year-effects in the data are more difficult to explain, and are likely due to natural variations in the availability of the fish in that time of the year and small variations in sampling effort (e.g. due to bad weather). Both the variability in age 0 and the apparent year-effects must be accounted for in the assessment model to be fitted to these data.

8.4 Biological Data

8.4.1 Mean length and mean weight at age in the stock.

Taking in consideration that the spawning season is very long, spawning is almost from September to June, and that the whole length range of the species has commercial interest in the Iberian Peninsula, with scarce discards, there is no special reason to consider that the mean-weight at age in the catch is significantly different from the mean weight at age in the stock.

8.4.2 Maturity at age

Maturity ogive estimation procedures are detailed in Stock Annex. In WGANSA 2011 a working document has been presented (Murta, Costa, and Gonçalves, 2011) showing the possible variation in SSB caused by poor coverage of the ages range when sampling for the maturity ogive. The Group discussed this problem, and it has been decided to use a single maturity ogive for the whole assessment period, which is an average of all maturity ogives estimated in the past, with the values for each age weighted by the corresponding number of samples that were used to estimate it. The resulting maturity ogive is described below. It was also decided to only make drastic changes to the maturity ogive in the case that strong evidence arises, based on as appropriate number of samples, showing that the proportion of fish mature at age has changed.

Age	0	1	2	3	4	5	6	7	8	9	10
Maturity	0	0	0.36	0.82	0.95	0.97	0.99	1.0	1.0	1.0	1.0

8.4.3 Natural mortality

The procedure in estimation of natural mortality rate is detailed in Stock Annex. The natural mortality used in the assessment is:

Age	0	1	2	3	4	5	6	7	8	9	10
Nat Mort	0.9	0.6	0.4	0.3	0.2	0.15	0.15	0.15	0.15	0.15	0.15

8.5 Assessment of the state of the stock

8.5.1 Stock assessment

The stock assessment has been performed as agreed during the latest benchmark (ICES, 2011), with the settings and method as described in the Stock Annex. For further details see the Stock Annex and 2011 report (WGANSA 2011).

The only tuning data included in the assessment was the combined series from the Portuguese and Spanish bottom-trawl surveys. In 2012 Portuguese survey was not carried out then the combined survey index for 2012 could not be estimated. Due to this, the stock assessment was performed without tuning index for 2012.

The survey data are very noisy, especially in the younger ages. This variability is partially due to natural causes and partly due to the low availability of very young fish to the fishing gear of the survey, because of a more pelagic behaviour (being the gear a bottom-trawl) and a distribution closer to the shore, where it is frequently difficult to trawl. For this reason, the age 0 is excluded from the tuning data used in the assessment.

Strong year-effects in the survey data are present as large fluctuations in overall abundance from year to year (e.g. Figure 8.5.1.1) but also in differences in the proportions at age from year to year (Figure 8.5.1.2). To account for these characteristics of the data set, four selectivity vectors of parameters were estimated (Figure 8.5.1.3). For the catch proportions at age, two selectivity parameter vectors were estimated (Figure 8.5.1.3). In all selectivity vectors of parameters, ages above 8 were kept constant and with the same value estimated to age 8 (which was the reference age).

The summarised results of the stock assessment are shown in Figure 8.5.1.4 and Table 8.5.1.1. The estimated SSB shows some decrease in the last five years but with a wide confidence interval and the fishing mortality shows a significant decrease in last two years. By other hand the recruitment shows an important increase in last two years although with wide confidence intervals. For the estimated spawning stock biomass (SSB) and recruitment series, the pairs SSB and recruitments obtained in the current assessment are showed in Figure 8.5.1.5.

8.5.2 Reliability of the assessment

Given the high fluctuations in total biomass from year to year as measured by the survey, and the fact that horse mackerel can be considered a long-lived species (living more than 30 years), it is unlikely that the large fluctuations observed (Figure 8.5.1.1) correspond to actual fluctuations of biomass. A more probable hypothesis is that they are due to fluctuations in availability due to natural causes.

Therefore, to force the model to fit well to the biomass index would result in a poor fit to other data sources and could make the model to provide spurious results. Thus, the biomass index is mainly helping the model to estimate an overall level of biomass, and the fitted values can be seen as a rough smoother for the variable values of the index (Figure 8.5.1.1). Moreover, we have to take in consideration that there is not survey index for last year.

The landings of this stock are believed to be fairly accurate, given the good sampling coverage, few discards (according to onboard observers) and the existence of well-defined ageing criteria. Therefore, a higher weight was given to the data series of landings in weight, which was very well fitted by the model (Figure 8.5.2.1).

A good fit was also obtained for the proportions at age of catch in numbers (Figure 8.5.2.2) and for the proportions at age of the abundance indices in number/hour from the bottom-trawl surveys, although in the last year there were not survey index (Figure 8.5.2.3). The bubble plots of the residuals corresponding to the fitting of those data are respectively in Figures 8.5.2.4 and 8.5.2.5.

The recruitment estimation shows a sharp increase in the last two years, last year is the biggest recruitment in temporal series. But it has wide confidence intervals. This could be due to a change in selection pattern caused by the increase in purse seine catches (targeting young ages) relative to the important decrease in bottom trawl catches (targeting older ages). The reduction required to accommodate the decrease of catches of old ages probably lead to infer strong recruitment in the last two years to fit at the same time the increase in catches of young ages. (Table 8.2.3.2, Figure 8.2.5.2).

The retrospective analysis suggests an overestimation of recruitment but a weak overestimation of SSB and minor changes in F in the previous assessment (Figure 8.5.2.6). All the former considerations puts in doubt the reliability of the strength of this recent years classes.

8.6 Short Term predictions

Deterministic short-term forecasts were made with the software MFDP, assuming a constant recruitment corresponding to the geometric mean of all estimated recruitments, except the one for the last year in the assessment. For the forecasts, the recruitment estimated for 2012 was also replaced by that average recruitment. The weights at age in the stock and in the population, and the fishing mortality used for the forecasts were those of the last assessment year. Status-quo fishing mortality was calculated as the mean of fishing mortalities of ages 2 to 10 in the last two years. Age-1 abundance in 2013 (=1042.99) is estimated from Recruitment at age 0 in 2012 (=2695.24) (Geometric mean) accounting for the M at age 0 (=0.9) and F=0.0494, which produces the observed catches at age 0 in 2012 (=85973 Thousands). The input data used for the forecasts is in Table 8.6.1.

Table 8.6.2 shows the management options table obtained from the deterministic short-term forecasts. According to those results, and with the assumptions described above, only with a Fsq (0.072) for 2013 are 40000 tons. Predicted SSB for 2013 is 224000 tons. If F remains at F sq level, the predicted yield corresponds to a increase of 38% correspondent to a catch level in recent years (average 24800 tonnes 2009-2012). Predicted SSB for 2014 is 303 thousand tonnes, which means an increase of 27% with respect to the estimated 2012 SSB.

The forecast presented in Section 8.6 is deterministic; hence no estimate of uncertainty is calculated. Sources of uncertainty in the outcomes are the uncertainty in the last recruitments, the assumptions on mean fishing mortality with a significant decreasing and the expected change in fishery selection pattern in last year.

8.7 Reference points and harvest control rules for management purposes

Reference points to be used for management were never proposed for this stock since the revision of the stock boundaries was made. Given the apparent stability in the exploitation and dynamics of this stock during the assessment time period (lack of contrast in the data), and the lack of a well-defined stock-recruitment relationship, the calculation of MSY reference points for fishery management has to be based on proxies calculated in equilibrium conditions. This approach is far from being satisfactory, and any points calculated in these conditions must be seen as provisory, and subject to revision as soon as an acceptable stock-recruitment relationship is available (e.g. when the time series of catch data can be extended in the past).

A yield-per-recruit analysis was therefore carried out this year using the software MFYPR using identical options and input data files to the ones used for the short-term forecasts. The results of this analysis are shown in Table 8.7.1. An estimate for Fmax, which is commonly used as a proxy for Fmsy, could not be obtained. However, it was possible to calculate F0.1 (0.15) and F35%SPR (0.11). The Group has discussed the use of these two candidates for Fmsy proxies, and was of the opinion that F35%SPR was a more sensible option, because of the way it is defined, which has stronger biological basis than F0.1, and because is close to the levels of F estimated for the assessment time period. The option of the group in this matter is coincident with the opinions of many authors who advocated F35%SPR as a generally desirable proxy for Fmsy (Gabriel and Mace, 1999 and references therein). The value of F35%SPR (0.11) as a proxy for MSY this proposed by this WG for consideration of ACOM

8.8 Management considerations

Several estimates obtained during the assessment of this stock show no signs of depletion and indicate an exploitation level that seems sustainable. The level of the fishing mortality rates is low, although that is also a cause of the high values for natural mortality that were adopted during the latest benchmark assessment. A conservative Fmsy proxy calculated in equilibrium conditions (F35%SPR) is higher than most of the estimates obtained for the fishing mortality rates. Nevertheless, all these indicators of the condition and state of exploitation of the stock are based on estimates that have a very high level of uncertainty associated, which is clear from the observation of the large asymptotic confidence intervals for F and SSB. The current assessment points to fluctuating F slightly below the propose FMSY sometimes reaching the FMSY value.

Therefore, and from a precautionary point of view, a too optimistic advice for stock exploitation should be avoided. The catches of horse mackerel are currently mainly limited by effort limitations of the bottom-trawl fleets, due to management plans for other species caught in the same mixed-fisheries (e.g. hake), and to a low demand of this species in the market, which makes its price to drop sometimes to levels unprofitable to fishermen. The TACs of the latest years (for example at 30800 t in 2012) were not achieved, and according to the short-term forecasts performed a Fmsy proposal (F35%SPR =0.11) will result in higher allowable catches (at about 35 000 t) than recent levels (which are about 24000 t). Thus, a TAC for 2014 similar to the one of 2013 would allow some increase of catches while keeping F at a likely sustainable level, and would maintain the same fishing opportunities for the industry, while taking into account the high uncertainty of the estimates related to the state of the stock.

This stock has supported a stable exploitation level for a long time period. It is clear that the apparent stability in the overall exploitation level is due to a decrease in fishing mortality in some fleets and an increase in others. The Spanish bottom-trawl fleet operating in subdivision IXa North increased during the last decade passing from less than 20% of the total catches until 2003 to a level of 37% of the total catches in 2010. But in the last two years seems to have been a new change in exploitation pattern since bottom trawl fleet operating in subdivision IXa North has had a sharp decrease in landings and there has been a significant increase in purse seine landings in the same period.

The traditional exploitation pattern across fleets has been, for a long time, the targeting of juvenile age classes. This targeting of juveniles at a moderate level of exploitation does not seem to have been detrimental to the dynamics of this stock, which has been stable along the years. However, both artisanal fleets and the Spanish bottom-trawl fleet target adult fish, especially above 6 years old. There is a migratory pattern of southern horse mackerel that makes age classes not evenly distributed along the stock area, with old fish mostly present in the waters of Galicia and northern Portugal.

Table 8.2.3.1 Time series of southern horse mackerel historical catches (in tonnes).

Year	Total Catch
1991	34,992
1992	27,858
1993	31,521
1994	28,441[1]
1995	25,147
1996	20,400[1]
1997	29,491
1998	41,564
1999	27,733
2000	26,160
2001	24,910
2002	22,506 // (23,663)*
2003	18,887 // (19,566)*
2004	23,252 // (23,577)*
2005	22,695 // (23,111)*
2006	23,902 // (24,558)*
2007	22,790 // (23,424)*
2008	22,993 // (23,593)*
2009	25,737 // (26,497)*
2010	26,556// (27,216)*
2011	21,875// (22575)*
2012	24,868//(25316)*

(*) In parenthesis: the Spanish catches from Subdivision IXa South are also included. These catches are only available since 2002 and they will not be considered in the assessment data until the rest of the time series be completed.

([1]) These figures have been revised in 2008.

Table 8.2.3.2. Southern horse mackerel. Landings by gear with and indication (in parenthesis) of the percentage that represent those landings.

	Gear		
Year	Bottom trawl	Purse seine	Artisanal
1992	14,651 52.6%	9,763 35.0%	3,445 12.4%
1993	20,660 65.6%	7,004 22.2%	3,841 12.2%
1994	13,121 46.2%	12,093 42.6%	3,202 11.3%
1995	15,611 62.1%	7,387 29.4%	2,137 8.5%
1996	13,379 65.8%	5,727 28.2%	1,228 6.0%
1997	14,576 49.3%	13,161 44.6%	1,800 6.1%
1998	16,943 40.7%	22,359 53.8%	2,287 5.5%
1999	10,106 36.4%	15,781 56.9%	1,855 6.7%
2000	12,697 48.5%	11,237 43.0%	2,227 8.5%
2001	12,226 49.1%	11,048 44.3%	1,637 6.6%
2002	12,307 54.7%	8,230 36.6%	1,969 8.7%
2003	10,116 53.6%	6,523 34.5%	2,248 11.9%
2004	16,126 65.9%	5,700 23.3%	2,658 10.9%
2005	14,029 61.8%	6,040 26.6%	2,621 11.6%
2006	15,019 62.9%	5,430 22.7%	3,445 14.4%
2007	13,705 60.1%	6,775 29.7%	2,308 10.1%
2008	12,380 53.8%	7,670 33.3%	2,949 12.8%
2009	15,075 58.6%	6,669 25.9%	3,984 15.5%
2010	16,062 59.0%	6,847 25.2%	4,308 15.8%
2011	11,038 50.40%	7,301 33.30%	3,530 16.40%
2012	7,839 30.97%	12,897 50.95%	4,579 18.09%

Table 8.2.3.3. Discards length distribution (individual thousand) and discard catch (t) estimations for southern horse mackerel of Spanish fleet in 2012. Discard sampling was raised to effort.

	IXa-N		IXa-S		Total	
Sem	1st	2nd	1st	2nd	1st	2nd
Weight (t)	0.1	2.7	148.1	64.3	148.2	67.0
CV	86	61	66	38	66	36
Trip Samp. level	11	12	23	17	34	29

Length (cm)	1st	2nd	1st	2nd	1st	2nd
4	0	0	49	49	49	0
5	0	0	98	98	98	0
6	0	0	33	33	33	0
7	0	0	404	404	404	0
8	0	0	310	310	310	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	0	0	30	30	30	328
13	0	0	59	59	59	49
14	0	0	30	30	30	163
15	0	0	738	738	738	368
16	0	26	1066	1066	1066	254
17	0	19	508	508	508	97
18	0	0	381	381	381	178
19	0	0	30	30	30	50
20	0	0	207	207	207	149
21	0	0	89	89	89	78
22	0	0	0	0	0	0
23	0	0	30	30	30	0
24	0	0	30	30	30	0
25	0	0	30	30	30	0
26	0	0	0	0	0	0
27	0	0	0	0	0	0
28	0	0	0	0	0	0
29	0	0	0	0	0	0
30	0	0	0	0	0	0
31	0	0	0	0	0	0
32	0	0	0	0	0	0
33	0	0	0	0	0	0
34	0	0	0	0	0	0
35	0	0	0	0	0	0
36	0	1	0	0	0	1
37	0	0	0	0	0	0
38	0	0	0	0	0	0
39	0	0	0	0	0	0
40	0	0	0	0	0	0
41	0	0	0	0	0	0
42	0	1	0	0	0	1

Table 8.2.5.1. Southern horse mackerel. Time series of catch at age data in number (thousands).

	AGES											
YEAR	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11+**
1992	11684	95186	145732	40736	12171	9102	5018	6864	5155	4761	13973	14354
1993	6480	66211	137089	100515	35418	13367	12938	10495	6597	5552	4497	14442
1994	12713	63230	86718	96253	28761	7628	4398	3433	5209	4834	6047	12264
1995	7230	55380	31265	52030	28199	11010	4003	3139	2720	3352	2530	31343
1996	69651	13798	14021	28125	33937	9861	6611	4501	4164	5504	3306	14243
1997	5056	295329	112210	26236	17168	12886	7780	7169	3938	3867	2425	8847
1998	22917	95950	320721	68438	18770	11317	9712	20627	12760	6686	6212	11323
1999	51659	29795	26231	66704	42960	15700	13840	7555	4175	4790	2475	7417
2000	12246	72936	23547	41618	35968	18643	17254	12118	7915	5227	3124	3557
2001	105759	77364	31261	24104	23721	16794	15391	14964	9795	3310	2023	3989
2002	18444	94402	84379	26482	13161	11396	10263	12501	10156	7525	3607	4433
2003	40033	6830	36754	28559	21931	12790	14751	13582	10631	6492	3531	2333
2004	7101	126797	58054	18243	8328	13586	11836	14878	10542	3876	5258	5318
2005	21015	108070	49197	24289	17877	11334	11179	7927	9124	7445	5502	11420
2006	3329	92563	92896	22665	6738	13176	11892	6029	7303	8070	8947	15322
2007	2885	16419	27667	44357	20534	8187	4459	3563	5975	4748	4943	30001
2008	48380	54167	31951	28058	16616	7194	4782	3660	4579	3975	4537	24990
2009	22618	85415	32416	8482	9774	7162	3289	2860	2791	3579	4236	39096
2010	81048	102016	33906	17496	11979	7569	3847	3942	2452	2671	2977	32284
2011	85973	23285	20985	19081	15046	7198	4271	3511	2884	5247	4638	22088
2012	201691	119136	30060	13964	14547	7693	5322	4373	2731	3218	4373	14562

Purse seine

	0	1	2	3	4	5	6	7	8	9	10	11+
1992	6977	51859	73537	21162	4860	2677	1362	1973	1299	1204	2572	2402
1993	6293	51337	83236	16597	4355	795	512	819	544	862	667	1842
1994	7634	45429	45987	39236	11267	2838	1379	1036	1640	1691	2550	3530
1995	3311	42111	12457	27030	14822	4224	854	445	163	362	217	2247
1996	38888	3446	3801	8189	8955	2917	1621	1107	1022	2003	891	4301
1997	2211	114184	42908	9797	6407	5775	4380	5300	2707	2831	1539	3672
1998	18294	59225	112386	34393	9893	6028	5838	15381	8920	3621	2760	2041
1999	23481	18237	9440	41032	31471	10684	7777	3835	2092	2465	764	1328
2000	11068	35861	8832	22508	23779	9645	5890	2291	876	338	172	231
2001	65468	51105	20260	14164	14394	9020	5035	3008	1170	290	227	644
2002	13660	32185	34516	13604	7895	6041	3804	3510	2435	1141	359	116
2003	22915	4609	17093	15338	7464	3944	5188	3784	2554	1447	675	260
2004	5258	42114	12332	5137	2673	3042	2600	2603	958	489	980	929
2005	17856	56690	18512	8881	5272	3365	2539	799	904	848	600	1026
2006	1637	27295	29845	7133	2103	2210	1506	1225	1638	1804	2037	1514
2007	2863	13802	12416	11231	8019	3800	1912	1712	2799	1667	1323	4186
2008	42868	41050	9766	4672	3729	2223	2138	1918	2063	1877	1707	3544
2009	18016	65130	17157	2736	3551	2078	1139	1206	1041	1168	1136	3200
2010	70206	41433	11571	2766	2058	1531	1038	904	446	377	561	1598
2011	76225	18619	10553	7915	5197	1941	1480	719	315	707	723	1881
2012	193478	96833	12558	5530	7261	3945	1375	1991	1106	1282	1279	1268

Table 8.2.5.2. Southern horse mackerel. Catch in number by gear .

Bottom trawl

	AGES											
YEAR	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11+**
1992	4707	43326	72194	19569	7265	6349	3562	4339	3125	2623	7008	6134
1993	98	8739	40094	78016	28660	10904	10401	8174	5166	3923	3319	9412
1994	3413	16252	37679	55079	16322	3926	2138	1559	2530	2200	2207	5223
1995	3917	12983	18292	22807	11447	5375	2541	2280	2299	2739	2138	25610
1996	30763	10340	10123	19245	23331	6326	4524	3063	2772	3245	2211	8611
1997	2828	180543	68330	15055	7846	4536	2087	1216	811	801	608	4360
1998	4444	36544	205609	32994	7151	3427	2487	3562	3100	2418	2724	7225
1999	28176	11492	16059	23745	8653	2914	3643	2570	1650	1932	1614	5525
2000	1106	35946	13685	18085	10763	7890	9180	7657	5546	4146	2544	2516
2001	39871	25245	10861	9401	8291	6329	8686	10261	7644	2630	1556	2606
2002	3572	59041	49402	12288	4796	4461	5100	7280	6068	5197	2671	3156
2003	14581	2077	18079	12556	13025	7525	7410	6940	6045	3966	2255	1526
2004	1352	77529	44171	12649	4758	9114	7787	9616	6875	2366	3823	3958
2005	2956	50643	30389	15100	12246	6636	6997	6190	7047	5546	3710	6705
2006	1666	59477	61175	14915	3798	9822	9492	3762	3871	4302	4908	9981
2007	19	2444	14853	31470	10967	2932	1983	1461	2681	2644	3135	21375
2008	5512	12787	21078	21828	10408	2984	1695	1166	1918	1678	2373	16881
2009	4552	19630	14558	5033	4758	4463	1581	1070	1183	1830	2579	27993
2010	10832	46074	15193	11434	6888	3661	1723	1728	1417	1531	1897	25218
2011	5984	3440	9440	9357	6696	2999	1871	1655	1426	3414	2876	16256
2012	7674	20041	14102	4899	4089	1915	2101	1356	987	1094	1799	7586

Table 8.2.5.2.(cont). Southern horse mackerel. Catch in number by gear .

Artisanal

	AGES											
YEAR	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11+**
1992	0	0	1	5	45	76	93	553	731	935	4393	5818
1993	89	6135	13760	5902	2402	1668	2025	1501	886	766	511	3187
1994	1666	1549	3052	1939	1171	863	882	839	1039	943	1290	3511
1995	2	286	516	2193	1929	1410	608	415	258	252	175	3485
1996	0	11	97	692	1651	618	465	331	370	255	205	1330
1997	17	602	972	1384	2915	2575	1313	653	420	235	278	814
1998	180	181	2726	1051	1726	1861	1387	1684	740	647	728	2056
1999	2	67	731	1927	2836	2102	2420	1151	433	394	98	564
2000	73	1129	1030	1024	1425	1108	2184	2171	1494	743	408	810
2001	420	1014	140	539	1036	1445	1671	1695	981	390	240	739
2002	1212	3176	461	591	471	895	1358	1711	1653	1187	578	1161
2003	2537	144	1581	665	1442	1320	2152	2858	2032	1079	601	547
2004	491	7154	1552	457	897	1429	1449	2659	2709	1021	455	431
2005	203	738	295	308	359	1332	1643	938	1174	1051	1193	3689
2006	26	5790	1875	617	837	1144	894	1041	1793	1964	2002	3826
2007	3	173	398	1656	1548	1456	563	390	496	438	486	4440
2008	0	330	1108	1557	2479	1987	948	576	599	420	456	4564
2009	49	654	701	713	1465	621	569	585	567	581	521	7903
2010	10	14509	7141	3295	3033	2378	1087	1309	589	763	519	5469
2011	3764	1226	992	1810	3153	2258	920	1137	1143	1126	1039	3951
2012	539	2263	3401	3535	3197	1833	1846	1026	637	843	1295	5708

Table 8.2.6.1.- Southern horse mackerel. Mean weight (kg) at age in the catch.

	AGES											
YEAR	0	1	2	3	4	5	6	7	8	9	10	11+
1992	0.03	0.03	0.04	0.07	0.1	0.13	0.15	0.17	0.19	0.2	0.23	0.3
1993	0.02	0.03	0.04	0.07	0.09	0.13	0.17	0.21	0.24	0.24	0.25	0.3
1994	0.04	0.04	0.06	0.07	0.09	0.13	0.16	0.19	0.23	0.25	0.27	0.34
1995	0.04	0.03	0.06	0.08	0.1	0.12	0.16	0.17	0.2	0.22	0.23	0.31
1996	0.02	0.05	0.07	0.09	0.11	0.14	0.17	0.19	0.22	0.24	0.26	0.31
1997	0.03	0.03	0.05	0.07	0.11	0.14	0.17	0.2	0.24	0.26	0.26	0.36
1998	0.03	0.03	0.04	0.07	0.1	0.13	0.17	0.21	0.17	0.24	0.25	0.35
1999	0.02	0.04	0.06	0.08	0.11	0.14	0.16	0.19	0.22	0.25	0.27	0.36
2000	0.02	0.03	0.05	0.09	0.11	0.13	0.16	0.19	0.22	0.24	0.25	0.31
2001	0.02	0.03	0.07	0.08	0.09	0.13	0.16	0.18	0.2	0.23	0.24	0.31
2002	0.03	0.03	0.04	0.07	0.1	0.12	0.15	0.17	0.2	0.23	0.25	0.31
2003	0.02	0.03	0.05	0.06	0.09	0.12	0.15	0.18	0.2	0.23	0.25	0.31
2004	0.04	0.03	0.05	0.08	0.12	0.16	0.18	0.21	0.23	0.25	0.27	0.33
2005	0.02	0.03	0.04	0.07	0.12	0.15	0.17	0.18	0.22	0.24	0.25	0.3
2006	0.03	0.03	0.05	0.06	0.09	0.13	0.14	0.17	0.19	0.23	0.25	0.33
2007	0.03	0.05	0.06	0.07	0.09	0.11	0.16	0.19	0.23	0.22	0.24	0.3
2008	0.02	0.05	0.06	0.08	0.1	0.13	0.15	0.17	0.2	0.21	0.23	0.32
2009	0.02	0.03	0.06	0.09	0.11	0.13	0.15	0.17	0.18	0.21	0.24	0.36
2010	0.02	0.04	0.06	0.08	0.11	0.14	0.16	0.18	0.19	0.2	0.24	0.38
2011	0.034	0.056	0.066	0.084	0.108	0.135	0.167	0.183	0.191	0.223	0.264	0.354
2012	0.02	0.03	0.07	0.10	0.13	0.16	0.18	0.19	0.21	0.24	0.28	0.37

Table 8.2.6.2. Southern horse mackerel. Mean length (cm) at age in the catch.

Year \ Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1992	14.9	15.6	17.5	19.8	23.2	25.8	27.4	28.6	29.6	31.2	31.5	32.6	33.3	33.9	34.7	36.8
1993	14.0	15.5	17.4	18.9	21.3	28.2	29.6	31.1	31.7	31.7	32.1	32.5	34.1	34.7	35.8	37.2
1994	13.4	14.6	18.1	21.1	22.7	24.8	27.0	29.5	31.2	31.7	32.4	32.2	33.3	34.2	34.4	36.5
1995	16.0	15.4	19.9	21.8	23.1	24.5	28.6	26.5	30.1	30.9	31.6	32.6	33.9	34.0	35.2	36.9
1996	13.3	19.0	19.7	21.8	24.7	26.3	28.0	28.6	30.3	30.7	31.5	32.0	33.4	32.5	36.2	37.0
1997	13.4	15.8	18.9	20.7	24.3	26.3	27.6	29.5	31.2	32.4	31.9	33.1	34.6	34.8	35.4	38.5
1998	14.5	13.9	15.9	20.4	23.5	25.5	28.3	30.3	26.9	31.7	32.0	32.7	33.4	34.5	36.4	39.1
1999	13.4	16.4	19.0	22.3	24.5	26.2	27.5	29.0	30.3	31.7	32.7	33.3	33.9	34.7	37.3	39.6
2000	13.6	16.4	18.4	21.7	24.8	26.0	27.2	28.6	30.2	30.8	31.5	32.3	32.7	34.2	34.5	35.0
2001	14.1	15.6	20.2	21.9	22.5	25.4	27.4	28.7	29.6	30.9	31.2	33.0	32.8	34.0	34.7	38.2
2002	15.0	15.7	17.5	20.3	23.1	25.4	26.6	28.0	29.6	30.9	31.8	32.6	34.2	34.7	35.4	36.9
2003	13.0	15.7	18.8	20.7	23.1	26.1	26.7	29.2	30.0	31.2	32.0	32.9	33.6	33.9	38.9	35.3
2004	16.2	14.4	17.2	21.2	24.0	26.7	28.1	29.4	30.5	31.6	32.3	32.2	33.0	32.2	36.4	35.9
2005	12.5	13.9	16.6	20.1	23.5	25.9	27.1	28.1	30.0	31.1	31.6	32.8	32.6	33.5	32.6	37.2
2006	14.6	14.7	17.0	19.2	22.2	24.6	25.6	27.2	28.7	30.3	31.5	33.2	34.0	35.9	36.7	37.0
2007	14.6	17.5	18.5	20.0	22.1	23.6	26.9	28.7	30.6	30.3	30.9	31.8	33.4	32.2	34.5	35.7
2008	13.0	17.3	20.5	22.3	24.0	25.4	26.5	27.7	28.8	29.6	30.5	31.3	32.2	33.5	35.6	37.2
2009	13.0	17.3	20.5	22.3	24.0	25.4	26.5	27.7	28.8	29.6	30.5	31.3	32.2	33.5	35.6	37.2
2010	13.1	15.8	18.4	20.8	23.4	25.4	26.9	27.8	28.6	29.2	31.2	31.7	33.5	34.7	36.7	38.0
2011	15.1	18.4	19.5	21.3	23.3	25.2	27.4	28.1	28.6	30.2	32.0	33.3	34.2	35.0	36.5	39.0
2012	15.7	15.8	18.4	22.8	24.9	26.5	27.8	28.8	29.9	31.1	33.2	34.4	35.5	36.7	39.4	39.8

Table 8.3.1.1. Time series of CPUE at age from Portuguese and Spanish bottom trawl surveys.

Portuguese October Survey

YEAR	AGES 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1992	442.6	481.6	154.5	54.1	24.6	9.8	6.7	6.9	3.6	3.0	4.0	0.7	0.8	0.3	0.1	0.1
1993	1843.0	248.0	249.0	153.2	36.3	4.8	2.8	1.7	1.0	1.1	0.7	1.7	0.5	0.3	0.1	0.1
1994	3.5	8.8	61.0	55.8	23.2	5.7	2.6	1.8	0.9	0.5	0.3	0.1	0.0	0.0	0.0	0.0
1995	20.6	81.2	116.4	70.5	31.4	6.0	1.2	1.4	0.4	0.2	0.2	0.3	0.3	0.5	0.1	0.2
1996*	1451.9	10.2	16.6	26.8	27.0	5.1	2.1	0.8	0.3	0.2	0.1	0.1	0.1	0.1	0.0	0.0
1997	1148.9	81.0	133.8	39.9	64.9	37.6	7.6	6.0	2.4	2.7	1.0	0.1	0.0	0.1	0.1	0.1
1998	94.0	39.7	111.7	16.2	6.0	3.3	1.8	1.8	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0
1999*	132.3	28.1	52.9	62.3	5.2	1.8	0.9	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
2000	3.0	19.2	25.8	29.0	14.1	7.9	4.1	1.2	0.6	0.1	0.0	0.1	0.0	0.0	0.0	0.0
2001	726.8	1.2	4.7	3.7	5.1	7.3	8.8	14.0	7.6	2.5	1.4	0.4	0.2	0.2	0.0	0.0
2002 [1]	41.6	2.6	8.9	14.6	11.6	6.0	1.9	1.3	0.9	0.5	1.0	0.3	0.2	0.1	0.1	0.0
2003*	75.2	9.5	9.6	18.5	16.5	4.7	2.6	1.6	1.0	0.6	0.2	0.0	0.0	0.0	0.0	0.0
2004	63.1	39.3	140.7	55.2	11.6	5.0	2.4	5.9	7.7	1.2	0.2	0.0	0.0	0.0	0.0	0.0
2005	379.1	1458.4	234.5	80.1	39.4	17.0	20.0	20.4	15.6	8.1	4.9	5.9	5.4	1.0	1.3	0.4
2006	92.0	94.1	250.5	62.4	3.7	12.0	8.6	7.1	2.9	1.6	0.7	0.2	0.0	0.0	0.0	0.0
2007	40.8	0.9	28.2	45.7	34.3	8.6	2.9	1.7	0.2	0.6	1.6	1.5	0.7	0.3	0.3	0.6
2008	51.7	26.7	41.1	23.7	30.4	21.1	2.9	1.0	1.4	2.0	1.4	1.0	0.5	0.9	0.6	2.0
2009	1725.2	81.5	121.2	44.4	36.0	10.0	2.7	1.5	1.2	0.7	0.6	0.5	0.9	1.9	0.5	0.9
2010	77.0	30.7	55.5	45.6	51.8	20.1	9.3	6.5	5.4	4.1	3.7	2.5	2.4	2.9	0.8	1.0
2011	89.1	35.7	34.5	56.8	53.7	13.2	5.8	8.2	4.0	5.1	5.7	2.1	1.8	1.8	1.0	0.9
2012	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Spanish October Survey (only Subdivision IXa North)

YEAR	AGES 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1991	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	1.9	0.8	0.8	2.7	1.4	1.7	1.8
1992	6.6	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.2	0.3	3.4	1.6	1.9	1.1	0.3	2.2
1993	92.1	1.7	5.2	3.9	0.4	0.0	1.2	5.2	5.7	8.7	5.2	10.8	2.2	1.6	0.4	1.0
1994	0.1	0.0	0.5	0.0	0.0	0.0	0.0	0.2	0.6	1.4	2.6	0.2	16.1	12.8	1.3	6.4
1995	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.8	2.5	4.0	8.8	2.4	2.2
1996	33.6	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.9	2.7	0.6	0.4	1.8	2.6	1.0	4.4
1997**	2.0	0.0	0.0	0.0	0.0	0.1	0.2	1.0	1.2	1.7	0.8	0.2	0.3	0.8	1.1	2.6
1998	1.0	0.0	0.0	0.0	0.0	0.0	0.1	0.9	0.5	0.3	0.1	0.0	0.1	0.1	0.0	0.2
1999	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.6	2.2	3.2	2.6	4.7	1.9	1.6	0.3
2000	0.5	0.0	0.0	0.0	0.0	0.0	0.4	2.8	3.7	3.2	0.7	0.6	0.4	0.5	0.3	0.7
2001	12.7	2.9	0.0	0.0	0.0	0.2	0.4	2.5	4.4	4.1	3.2	1.8	1.0	0.9	0.1	0.3
2002	0.1	0.0	0.0	0.0	0.0	0.0	0.6	1.2	7.3	7.1	8.9	10.4	3.5	4.5	1.3	2.3
2003	8.8	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.8	0.9	0.3	0.2	0.1	0.1	0.9
2004	90.0	1.2	2.5	16.2	5.4	4.6	1.7	1.3	0.7	0.3	0.8	0.1	0.3	0.0	0.1	0.1
2005	3520.4	0.0	0.0	0.0	0.3	0.4	0.3	0.3	0.5	0.5	0.1	0.6	0.3	0.2	0.1	0.0
2006	28.4	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.2	0.2	0.3	0.2	0.0	0.2
2007	1.4	0.0	0.0	0.0	0.1	0.2	1.0	1.3	1.6	0.8	0.6	0.6	0.2	0.2	0.2	0.2
2008	18.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.4	0.4	0.3	0.1	0.0	0.1	0.4
2009	84.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.1	0.8	0.7	0.3
2010	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.6	0.5	0.8	1.3	1.1
2011	1.5	0.0	0.0	0.1	0.1	0.3	0.4	0.6	0.5	1.1	1.2	0.1	0.1	0.0	0.2	0.6
2012	12.9	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.2

* The surveys were carried out with a different vessel

** Since 1997 another stratification design was applied in the Spanish surveys

1 In 2002 started a new series in which the duration of the trawling per haul has changed from one hour to thirty minutes

Table 8.3.1.2. Time series of CPUE at age from Portuguese and Spanish combined bottom trawl. It is showed with the period and the age plus was considered in the assessment.

	AGES											
YEAR	0	1	2	3	4	5	6	7	8	9	10	11+
1992	329.79	355.18	113.94	39.86	18.21	7.25	4.93	5.20	2.74	2.34	4.70	5.06
1993	1451.66	190.40	192.85	119.01	27.93	3.66	2.63	3.64	3.35	4.84	2.92	9.37
1994	2.92	7.18	49.83	45.48	18.92	4.68	2.11	1.47	0.88	0.91	1.18	13.04
1995	16.63	65.59	93.98	56.92	25.36	4.81	0.99	1.15	0.47	0.21	0.44	8.78
1996	1144.22	7.93	12.93	20.89	20.99	3.97	1.73	0.81	0.59	1.29	0.29	4.72
1997	844.43	59.50	98.27	29.34	47.67	27.65	5.73	4.98	2.40	2.92	1.17	3.49
1998	77.56	32.60	91.65	13.25	4.92	2.74	1.53	1.77	0.40	0.13	0.07	0.20
1999	104.55	22.21	41.75	49.25	4.13	1.42	0.82	0.32	0.34	0.99	1.15	3.66
2000	2.53	15.43	20.76	23.35	11.36	6.34	3.40	2.01	1.86	1.28	0.30	1.04
2001	545.08	1.90	3.51	2.73	3.79	5.49	6.71	11.50	7.63	3.66	2.41	2.61
2002	32.48	2.04	6.89	11.33	9.00	4.62	1.76	1.59	3.96	3.51	4.56	9.90
2003	62.51	7.54	7.57	14.64	13.03	3.73	2.06	1.30	0.85	0.74	0.48	0.66
2004	82.36	31.80	113.13	49.81	11.13	5.62	2.48	5.19	6.39	1.08	0.47	0.23
2005	1438.11	1189.30	189.50	64.68	31.95	13.92	16.24	16.54	12.74	6.70	4.02	11.63
2006	84.24	76.65	206.84	52.26	3.88	12.03	8.51	7.29	2.58	1.42	0.66	0.49
2007	34.22	0.72	23.33	37.78	28.41	7.16	2.69	1.78	0.64	0.71	1.55	3.26
2008	48.48	21.65	33.42	19.24	24.72	17.09	2.40	0.80	1.24	1.74	1.24	4.36
2009	1436.41	66.51	98.82	36.24	29.39	8.12	2.20	1.26	0.93	0.58	0.55	4.57
2010	64.94	31.91	33.91	34.16	47.54	14.94	4.81	6.39	4.12	3.95	1.57	11.06
2011	120.96	33.85	22.38	16.19	6.85	1.65	0.52	0.69	0.45	0.85	1.01	1.53
2012	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 8.5.1.1.- Southern horse mackerel. Final assessment. Stock summary table.

Year	Recruits (10*6)	SD Rec	Total SSB(ton)	SD SSB	Fmult	SD Fmult	Mean F(2-10)	Landings
1992	3866.9	631.4	295846	57620	0.093305	0.017911	0.11	27858
1993	2743.6	480.6	310750	62296	0.099310	0.020109	0.11	31521
1994	2702.3	482.4	314190	65860	0.081582	0.017152	0.09	28450
1995	3597.7	621.0	312986	68278	0.078184	0.016731	0.09	25132
1996	9380.2	1410.2	306826	69320	0.056847	0.012157	0.06	20360
1997	3095.1	531.9	311250	70362	0.079165	0.016919	0.09	29491
1998	1923.5	361.9	340346	75434	0.113241	0.024408	0.12	41661
1999	2883.8	510.3	358332	82138	0.070849	0.015769	0.08	27768
2000	2585.4	479.4	355334	84130	0.073888	0.016685	0.08	26160
2001	3062.7	573.0	349092	85716	0.073927	0.017004	0.08	24911
2002	1676.5	355.4	343804	86936	0.073037	0.017197	0.08	22506
2003	3277.3	646.2	334130	86794	0.062568	0.014773	0.07	18887
2004	3492.7	701.7	325348	86294	0.069064	0.016647	0.07	23252
2005	2065.9	452.6	317106	86182	0.072078	0.017983	0.08	22695
2006	993.8	252.6	320340	88842	0.081915	0.021437	0.09	23902
2007	1497.1	378.0	318152	91870	0.080902	0.022107	0.09	22790
2008	2320.9	610.0	294682	89540	0.086237	0.024857	0.09	22993
2009	1837.9	548.7	268408	86450	0.101958	0.031579	0.11	25737
2010	2108.6	724.4	247758	85322	0.107536	0.036100	0.11	26556
2011	5864.0	2212.7	230468	85424	0.076240	0.027616	0.08	21875
2012	16069.6	7010.8	222194	86500	0.068258	0.026533	0.07	24868

Table 8.6.1. Sourthern horse mackerel. Short-term forecast (2013-2015).

2013

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	2695.24	0.9	0	0.08	0.08	0.023	0.020592	0.023
1	1042.99	0.6	0	0.08	0.08	0.034	0.091121	0.034
2	1168.95	0.4	0.36	0.08	0.08	0.065	0.115176	0.065
3	247.643	0.3	0.82	0.08	0.08	0.102	0.103336	0.102
4	137.963	0.2	0.95	0.08	0.08	0.131	0.089041	0.131
5	124.853	0.15	0.97	0.08	0.08	0.162	0.066275	0.162
6	63.6221	0.15	0.99	0.08	0.08	0.184	0.063247	0.184
7	34.0311	0.15	1	0.08	0.08	0.194	0.06364	0.194
8	57.5454	0.15	1	0.08	0.08	0.213	0.06364	0.213
9	79.5917	0.15	1	0.08	0.08	0.237	0.06364	0.237
10	61.2083	0.15	1	0.08	0.08	0.281	0.06364	0.281
11	235.267	0.15	1	0.08	0.08	0.366	0.06364	0.366

2014

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	2695.24	0.9	0	0.08	0.08	0.023	0.020592	0.023
1		0.6	0	0.08	0.08	0.034	0.091121	0.034
2		0.4	0.36	0.08	0.08	0.065	0.115176	0.065
3		0.3	0.82	0.08	0.08	0.102	0.103336	0.102
4		0.2	0.95	0.08	0.08	0.131	0.089041	0.131
5		0.15	0.97	0.08	0.08	0.162	0.066275	0.162
6		0.15	0.99	0.08	0.08	0.184	0.063247	0.184
7		0.15	1	0.08	0.08	0.194	0.06364	0.194
8		0.15	1	0.08	0.08	0.213	0.06364	0.213
9		0.15	1	0.08	0.08	0.237	0.06364	0.237
10		0.15	1	0.08	0.08	0.281	0.06364	0.281
11		0.15	1	0.08	0.08	0.366	0.06364	0.366

2015

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	2695.24	0.9	0	0.08	0.08	0.023	0.020592	0.023
1		0.6	0	0.08	0.08	0.034	0.091121	0.034
2		0.4	0.36	0.08	0.08	0.065	0.115176	0.065
3		0.3	0.82	0.08	0.08	0.102	0.103336	0.102
4		0.2	0.95	0.08	0.08	0.131	0.089041	0.131
5		0.15	0.97	0.08	0.08	0.162	0.066275	0.162
6		0.15	0.99	0.08	0.08	0.184	0.063247	0.184
7		0.15	1	0.08	0.08	0.194	0.06364	0.194
8		0.15	1	0.08	0.08	0.213	0.06364	0.213
9		0.15	1	0.08	0.08	0.237	0.06364	0.237
10		0.15	1	0.08	0.08	0.281	0.06364	0.281
11		0.15	1	0.08	0.08	0.366	0.06364	0.366

Table 8.6.2. Short-term forecast (2013-2015) for southern horse mackerel. SSB corresponds to both sexes combined at spawning time.

MFDP version 1a

2013

Biomass	SSB	FMult	FBar	Landings
407	224	1	0.0722	24

2014					2015	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
407	242	0	0	0	430	266
0	242	0.1	0.0072	2	428	263
0	242	0.2	0.0144	5	425	261
0	242	0.3	0.0217	7	423	259
0	242	0.4	0.0289	10	420	257
0	242	0.5	0.0361	12	418	255
0	241	0.6	0.0433	14	415	252
0	241	0.7	0.0506	17	413	250
0	241	0.8	0.0578	19	410	248
0	241	0.9	0.065	21	408	246
0	241	1	0.0722	24	405	244
0	241	1.1	0.0795	26	403	242
0	241	1.2	0.0867	28	401	240
0	240	1.3	0.0939	30	398	238
0	240	1.4	0.1011	33	396	235
0	240	1.5	0.1084	35	394	233
0	240	1.6	0.1156	37	391	231
0	240	1.7	0.1228	39	389	229
0	240	1.8	0.13	41	387	228
0	240	1.9	0.1373	43	385	226
0	239	2	0.1445	46	382	224

Input units are thousands and kg - output in tonnes

Table 8.7.1. Results of yield per recruit analysis for southern horse mackerel by MFYPR (Multi-Fleet Yield per Recruit Program).

Yield per results

FMult	Fbar	CatchNos	Yield	StockNos	Biomass	SpwnNosJan	SSBJan	SpwnNosSpwn	SSBSpwn
0	0	0	0	2.5414	0.2532	0.956	0.1973	0.9412	0.1947
0.1	0.0089	0.0138	0.0016	2.4713	0.235	0.8898	0.1793	0.8752	0.1768
0.2	0.0179	0.0265	0.003	2.4079	0.2189	0.8303	0.1635	0.8159	0.1611
0.3	0.0268	0.0383	0.0042	2.3503	0.2046	0.7765	0.1494	0.7623	0.1471
0.4	0.0358	0.0493	0.0052	2.2978	0.1918	0.7277	0.1369	0.7138	0.1347
0.5	0.0447	0.0596	0.0061	2.2497	0.1804	0.6833	0.1258	0.6696	0.1236
0.6	0.0537	0.0692	0.0069	2.2056	0.1702	0.6428	0.1158	0.6293	0.1137
0.7	0.0626	0.0783	0.0075	2.1649	0.161	0.6057	0.1069	0.5924	0.1049
0.8	0.0716	0.0869	0.0081	2.1274	0.1527	0.5716	0.0988	0.5585	0.0969
0.9	0.0805	0.095	0.0086	2.0926	0.1452	0.5403	0.0915	0.5274	0.0896
1	0.0895	0.1026	0.0091	2.0603	0.1383	0.5114	0.0849	0.4987	0.0831
1.1	0.0984	0.1099	0.0094	2.0302	0.1321	0.4846	0.0789	0.4721	0.0772
1.2	0.1074	0.1169	0.0098	2.0022	0.1265	0.4599	0.0735	0.4476	0.0718
1.3	0.1163	0.1235	0.0101	1.9759	0.1213	0.4369	0.0685	0.4248	0.0669
1.4	0.1253	0.1299	0.0103	1.9514	0.1166	0.4156	0.064	0.4036	0.0624
1.5	0.1342	0.1359	0.0106	1.9283	0.1122	0.3957	0.0599	0.3839	0.0583
1.6	0.1432	0.1418	0.0108	1.9066	0.1082	0.3771	0.0561	0.3655	0.0546
1.7	0.1521	0.1474	0.011	1.8862	0.1045	0.3598	0.0526	0.3484	0.0512
1.8	0.161	0.1528	0.0111	1.8669	0.1011	0.3436	0.0494	0.3323	0.048
1.9	0.17	0.158	0.0113	1.8487	0.098	0.3284	0.0464	0.3173	0.0451
2	0.1789	0.163	0.0114	1.8315	0.0951	0.3141	0.0437	0.3032	0.0424

Reference point	F multiplier	Absolute F
Fbar(1-11)	1	0.0895
FMax	>=1000000	
F0.1	1.7054	0.1526
F35%SPR	1.2741	0.114
FSPR(4)	-99	

Weights in kilograms

FIGURE CAPTIONS

Figure 8.2.5.1. Southern horse mackerel. Bubble plot of proportions of the catch in numbers at age by year

Figure 8.2.5.2. Southern horse mackerel. Bubble plot of proportions of the catch in numbers at age by year, gear and country.

Figure 8.2.6.1. Southern horse mackerel. Time series of mean weight at age in the catch (from age 1 to 11).

Figure 8.5.1.1. Southern horse mackerel. Historical series of biomass index estimates from the combined bottom-trawl survey (solid black line) and by the assessment model (dashed red line).

Figure 8.5.1.2. Southern horse mackerel. Comparison of proportions at age of the abundance indices observed in catch data and those fitted by the AMISH model. Observed values =dots; fitted values = solid lines.

Figure 8.5.1.3. Southern horse mackerel. Selectivity patterns of survey index and catch data. Proportions of catches at age by selectivity period.

Figure 8.5.1.4. Southern horse mackerel. Final assessment. Stock summary. Plots of SSB, recruitment and fishing mortality. SSB and catch are in tons, and recruitment in thousands.

Figure 8.5.1.5. Stock-recruitment relationship for southern horse mackerel

Figure 8.5.2.1. Southern horse mackerel. Fitting of historical series of stock landings (solid green line) and estimated landings by the assessment model (dashed red line).

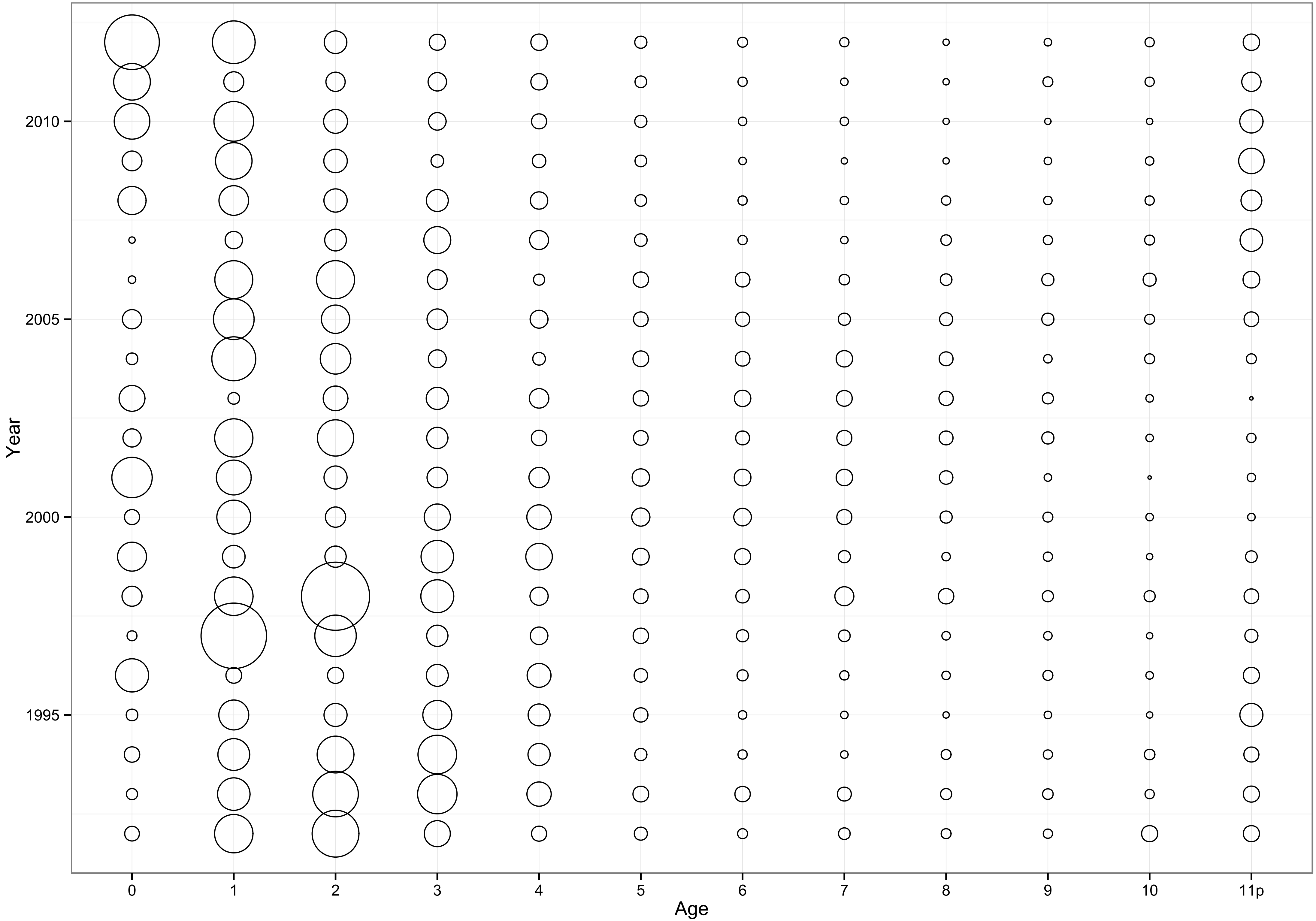
Figure 8.5.2.2. Southern horse mackerel. Comparison of proportions at age of the abundance indices observed in catch data and those fitted by the AMISH model. Observed values =dots; fitted values = solid lines.

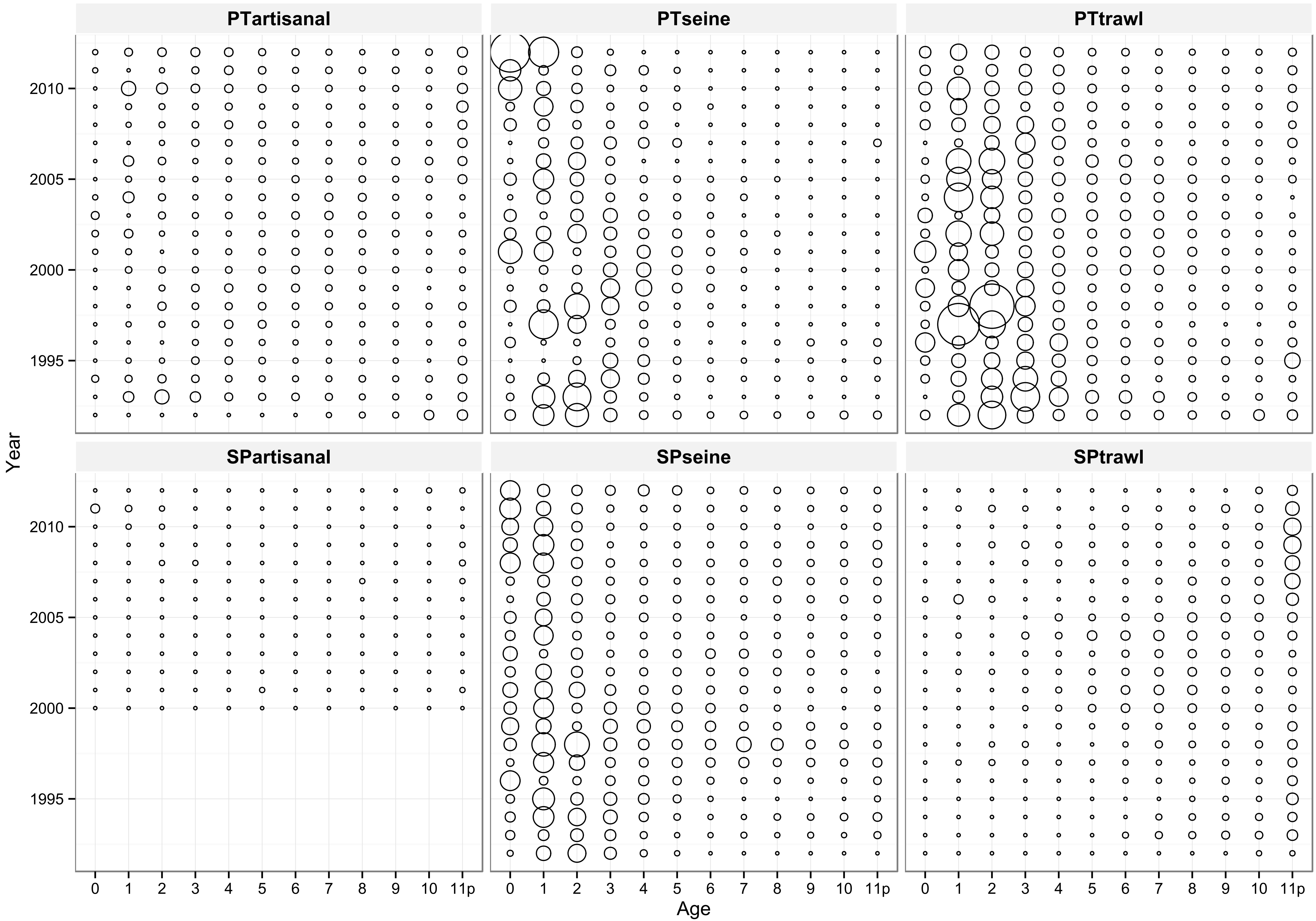
Figure 8.5.2.3. Southern horse mackerel. Comparison of proportions at age of the abundance indices observed in catch data and those fitted by the AMISH model. Observed values =dots; fitted values = solid lines.

Figure 8.5.2.4. Southern horse mackerel. Bubble plot of catch data residuals from the AMISH assessment.

Figure 8.5.2.5. Southern horse mackerel. Bubble plot of bottom trawl survey residuals from the AMISH assessment.

Figure 8.5.2.6. Southern horse mackerel. Retrospective analysis results. Trajectories of SSB, recruitment and F are shown.


Year
2010
2005
2000
1995
Age
0
1
2
3
4
5
6
7
8
9
10
11p


PTartisanal
PTseine
PTtrawl
SPartisanal
SPseine
SPtrawl
Year
2010
2005
2000
1995
Age
0
1
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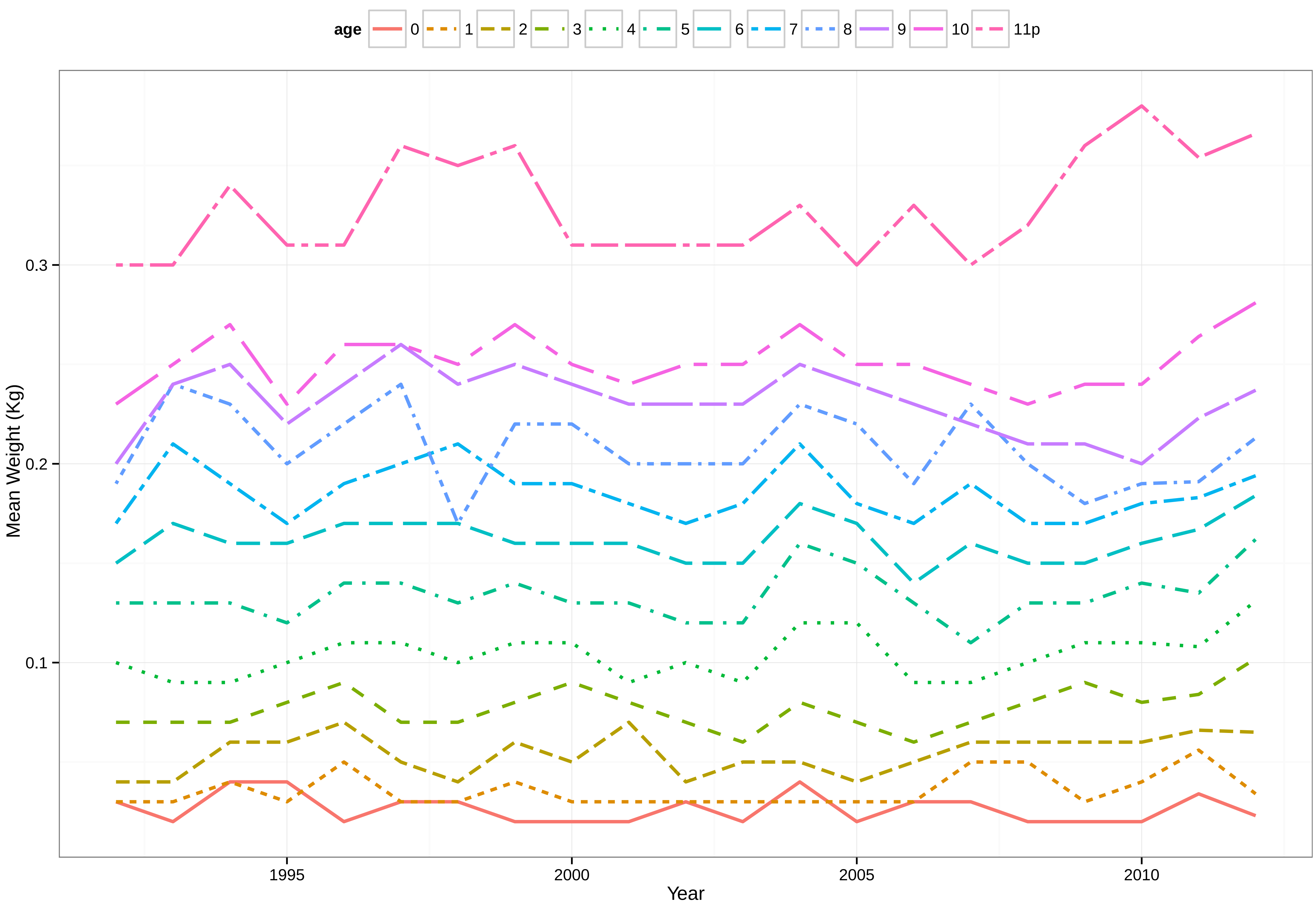
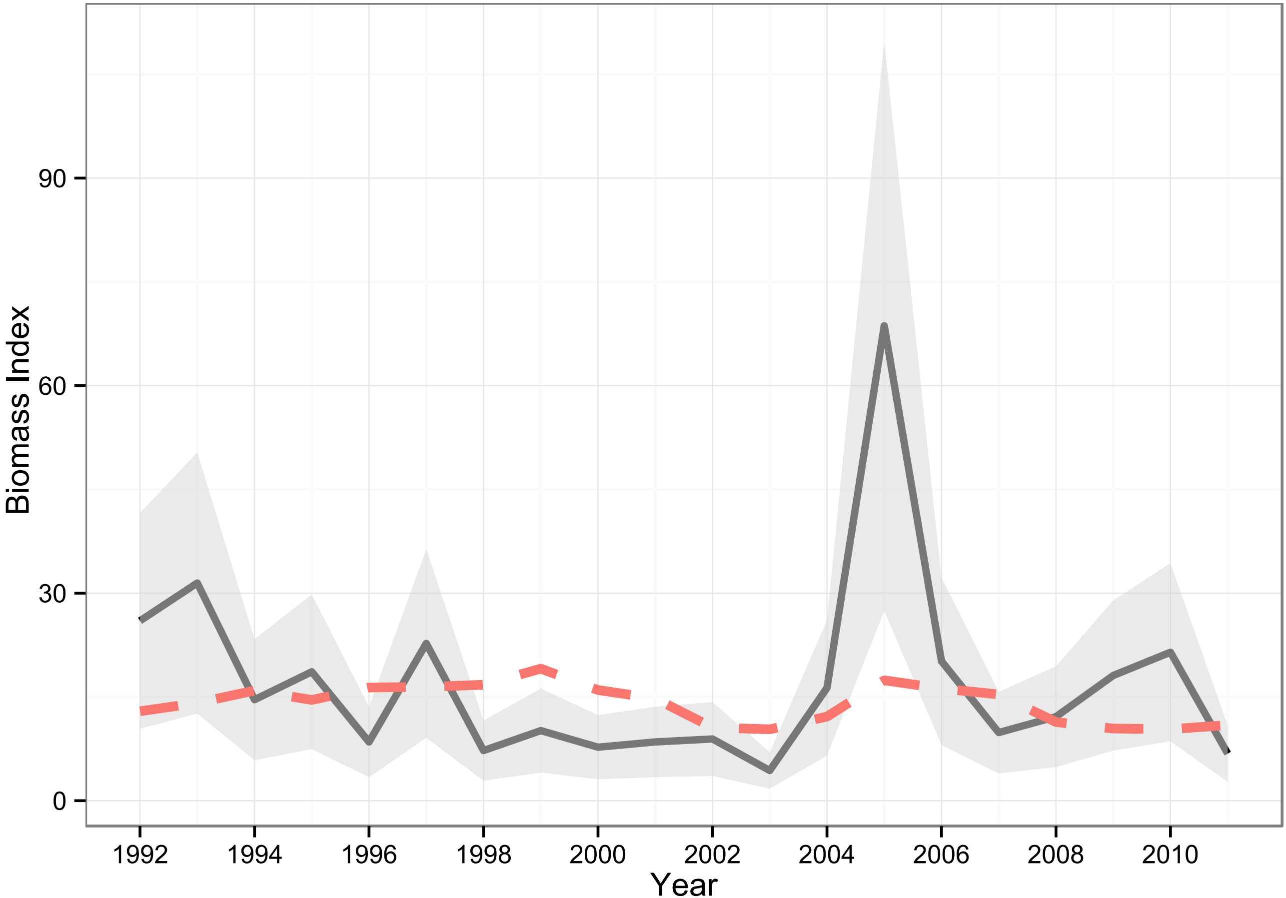
6
7
8
9
10
11p


age
0
1
2
3
4
5
6
7
8
9
10
11p
Mean Weight (Kg)
0.3
0.2
0.1
1995
2000
2005
2010
Year


Biomass Index
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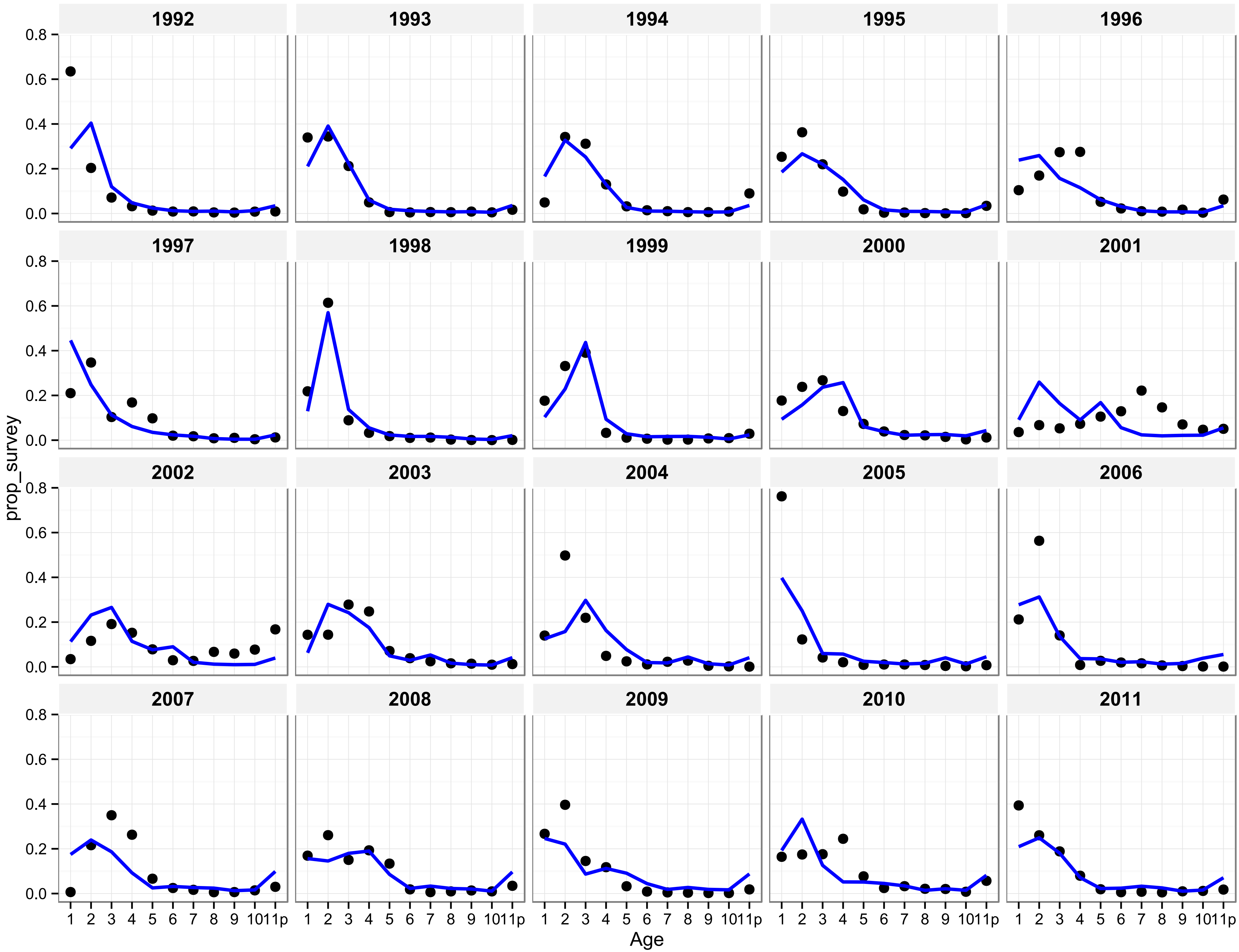
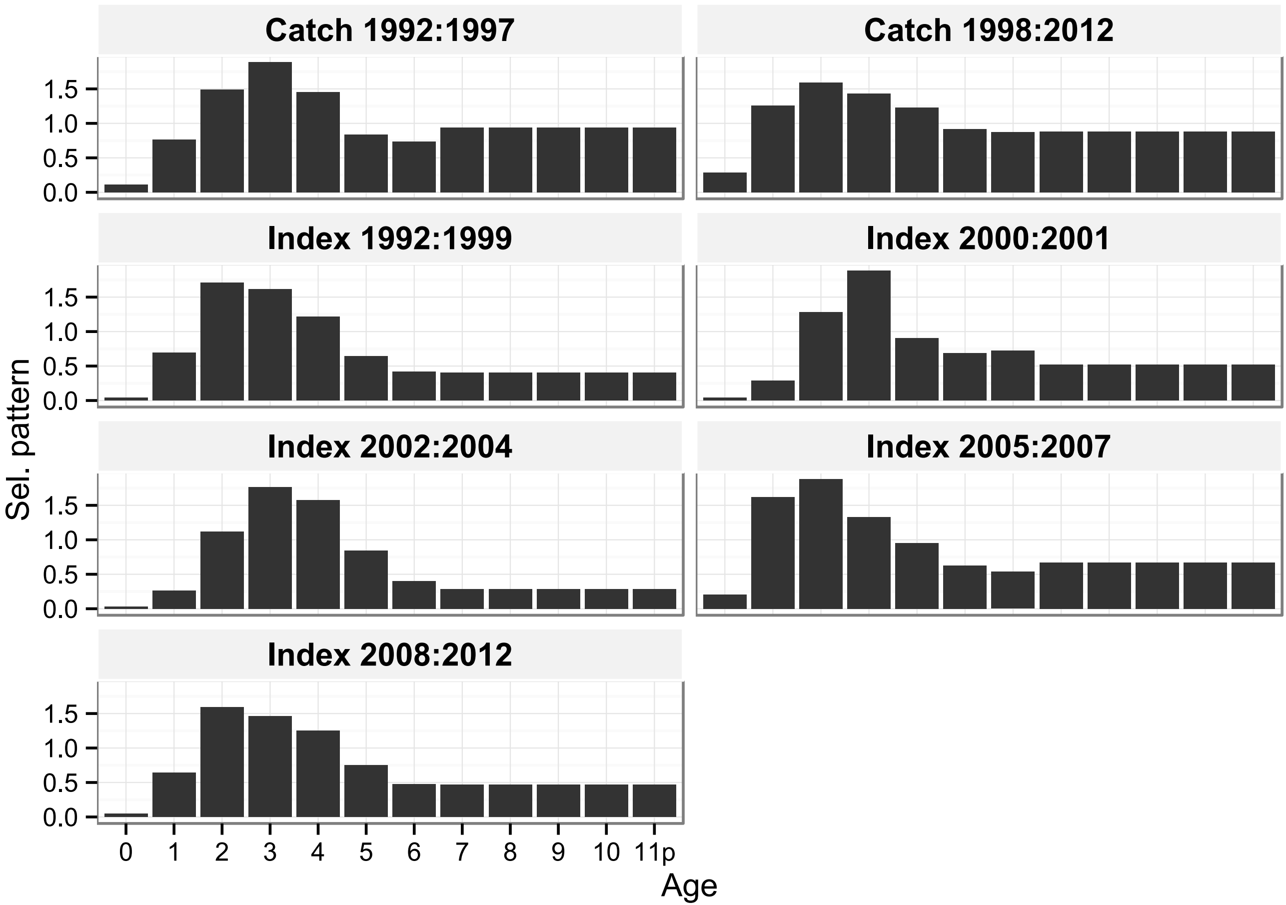
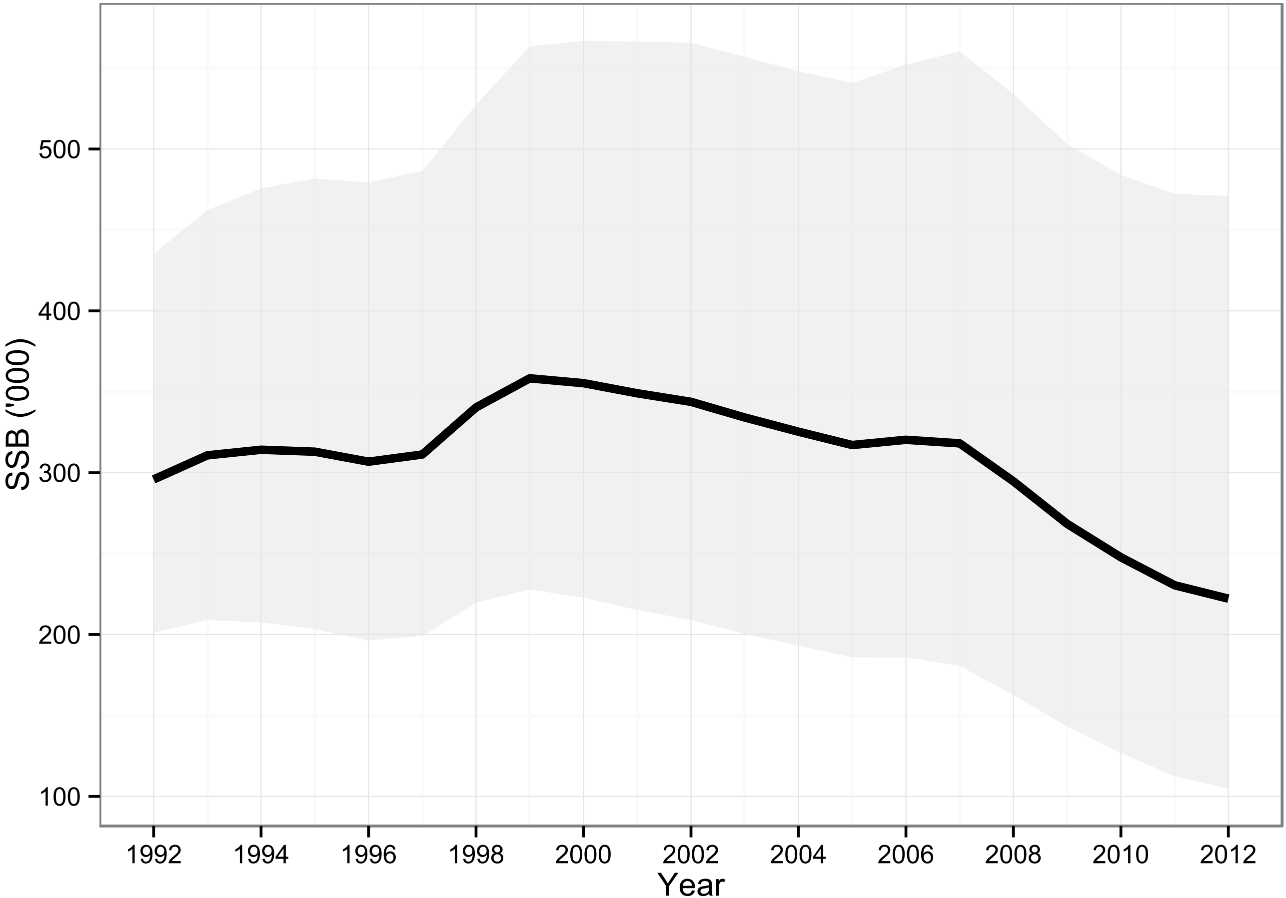
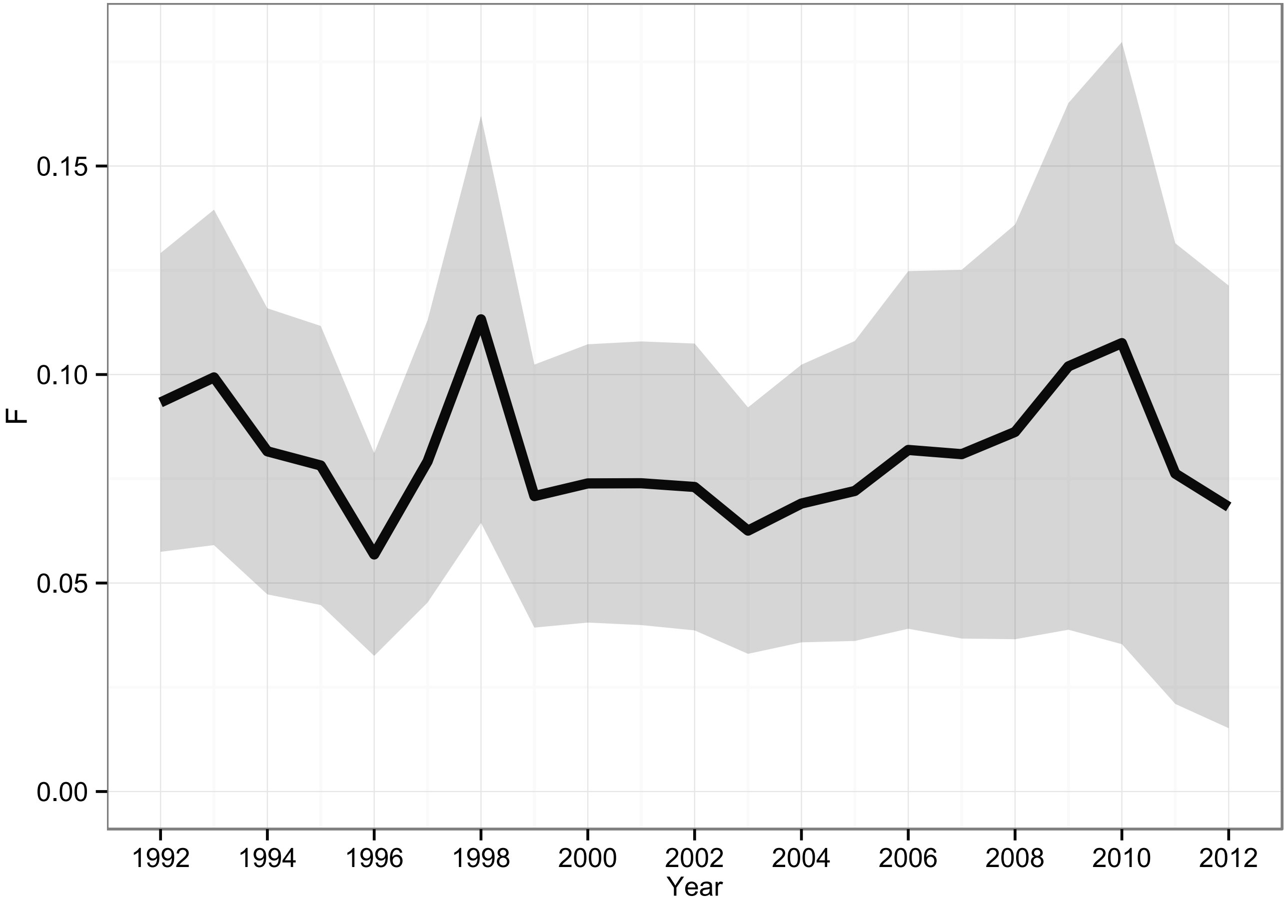
60
30
0
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year


1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
0.0
0.2
0.4
0.6
0.8
1 2 3 4 5 6 7 8 9 10 11p
prop_survey
Age



Catch 1992:1997
Catch 1998:2012
Index 1992:1999
Index 2000:2001
Index 2002:2004
Index 2005:2007
Index 2008:2012
Sel. pattern
0.0
0.5
1.0
1.5
0
1
2
3
4
5
6
7
8
9
10
11p
Age


500
400
300
200
100
SSB ('000)
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
Year


F
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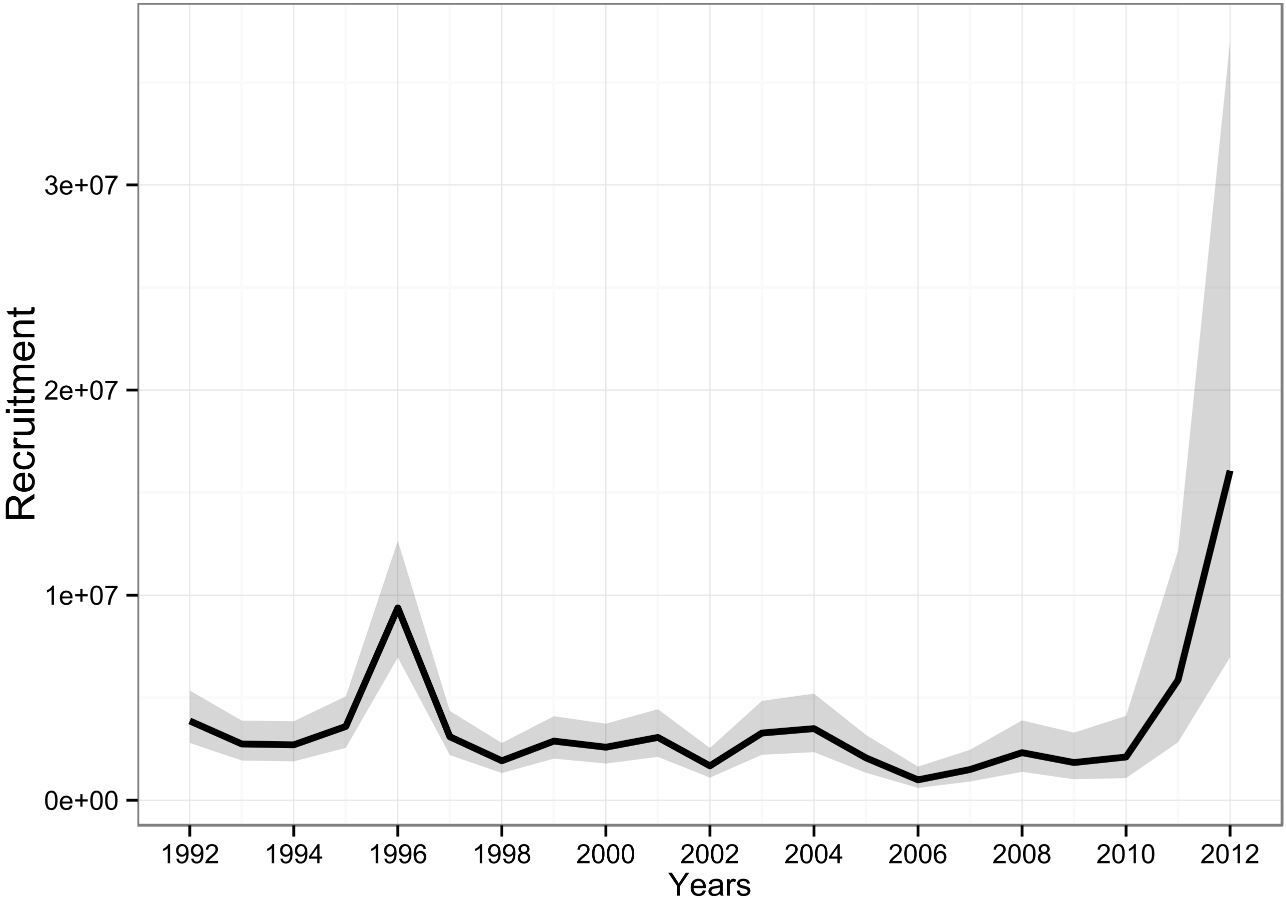
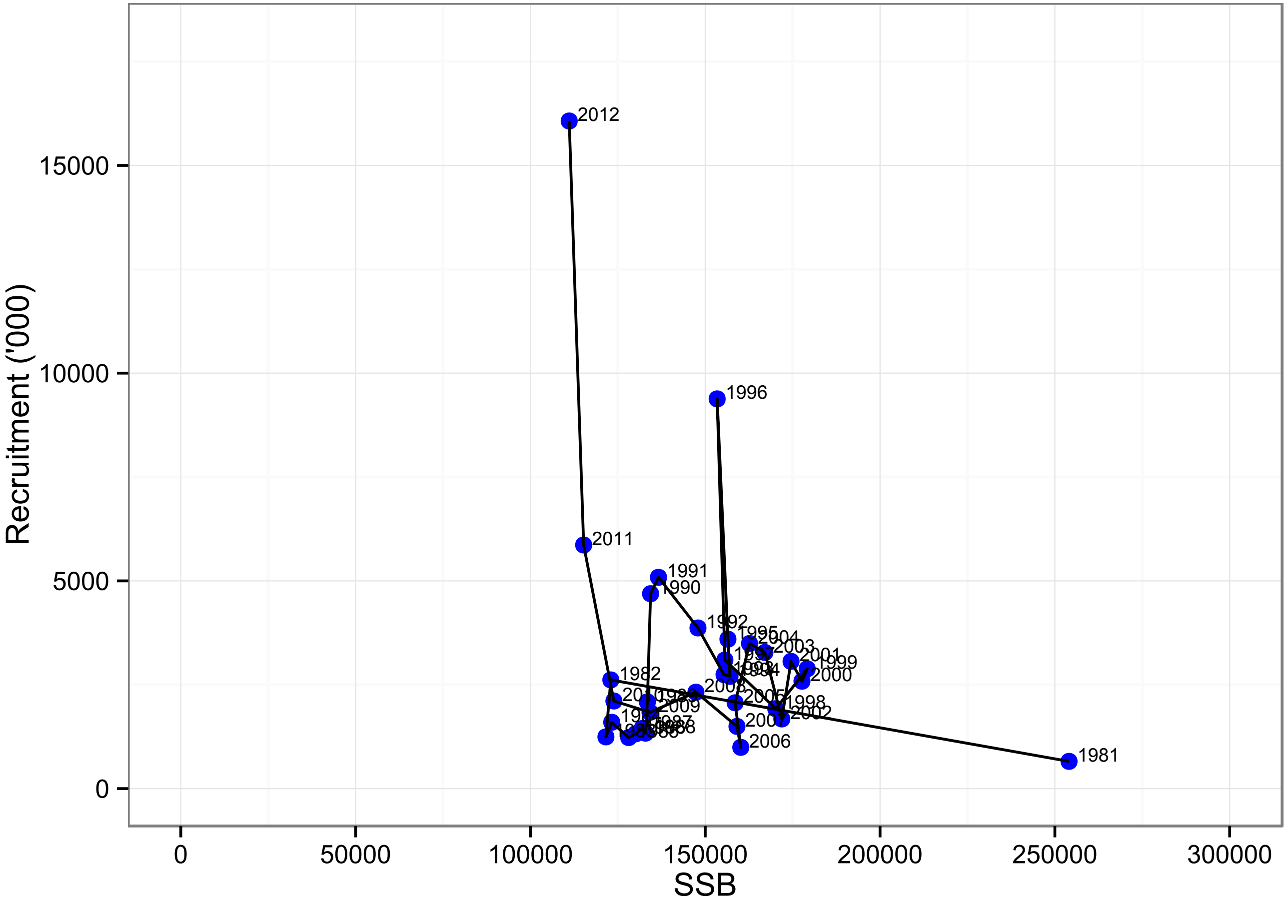
0.05
0.10
0.15
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
Year



3e+07
2e+07
1e+07
0e+00
Recruitment
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
Years



Recruitment ('000)
SSB
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5000
10000
15000
0
50000
100000
150000
200000
250000
300000
2012
2011
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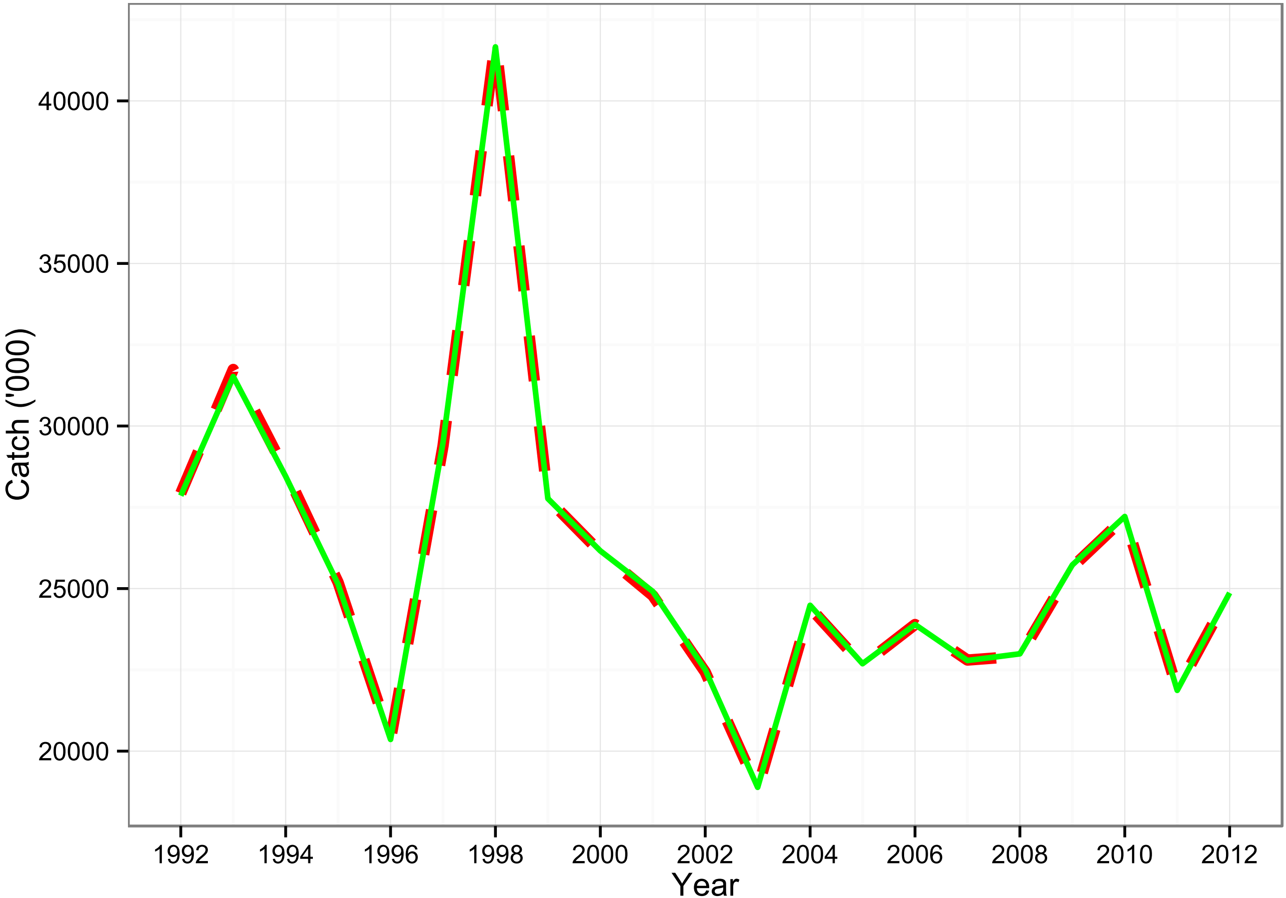
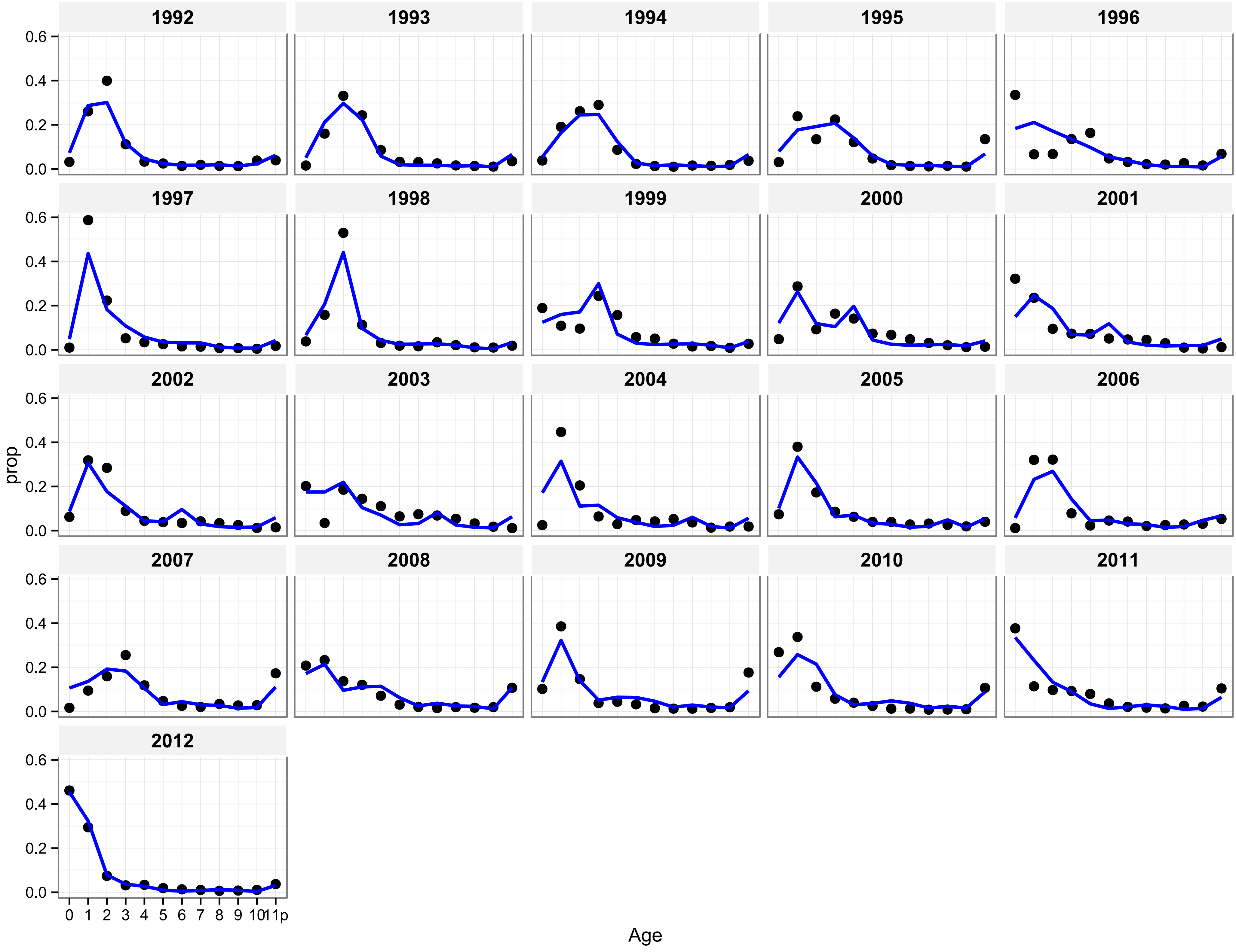
2002
2003
2001
1999
2000



Catch ('000)
40000
35000
30000
25000
20000
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
Year



1992
1993
1994
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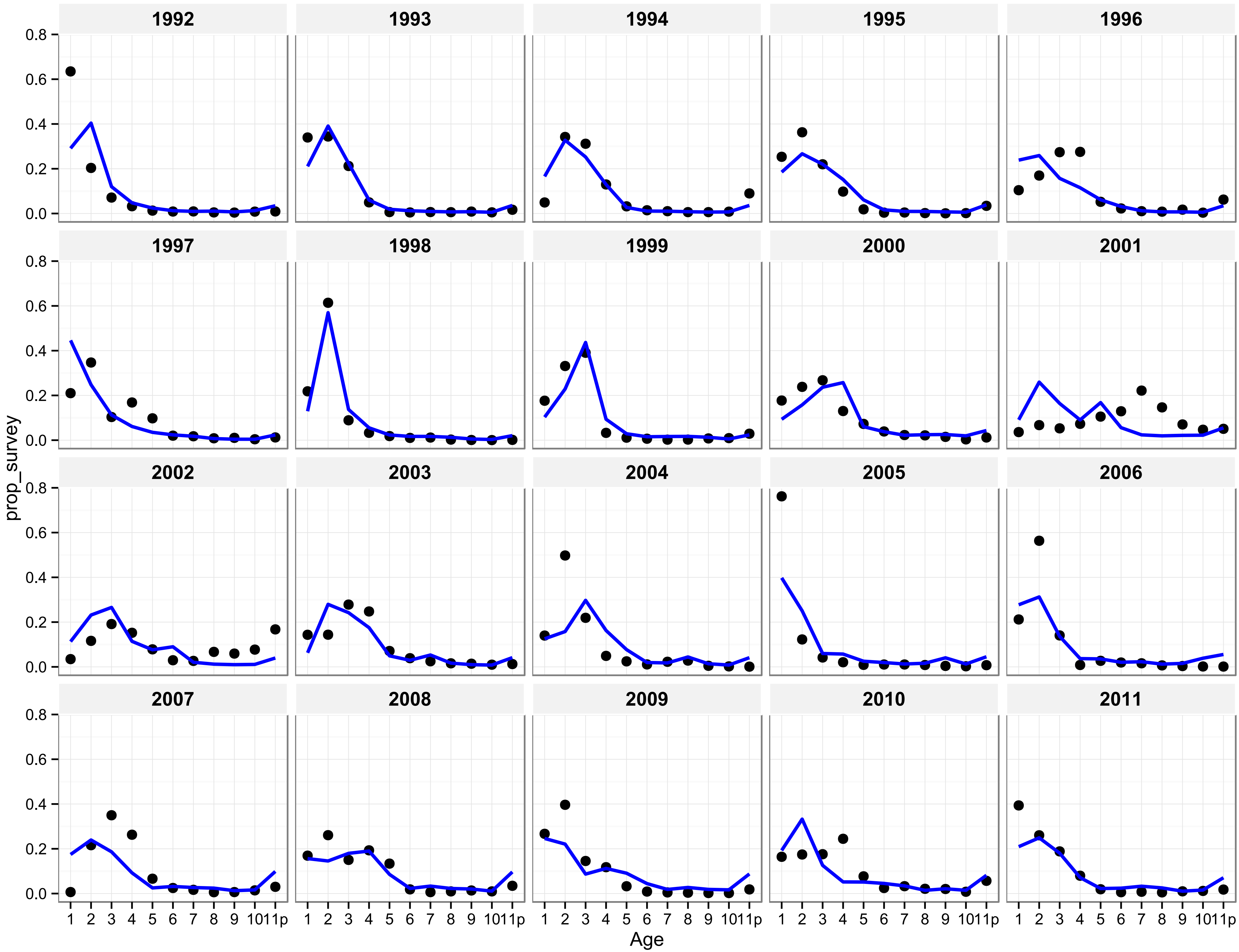
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
prop
0.0
0.2
0.4
0.6
0 1 2 3 4 5 6 7 8 9 10 11p
Age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1994
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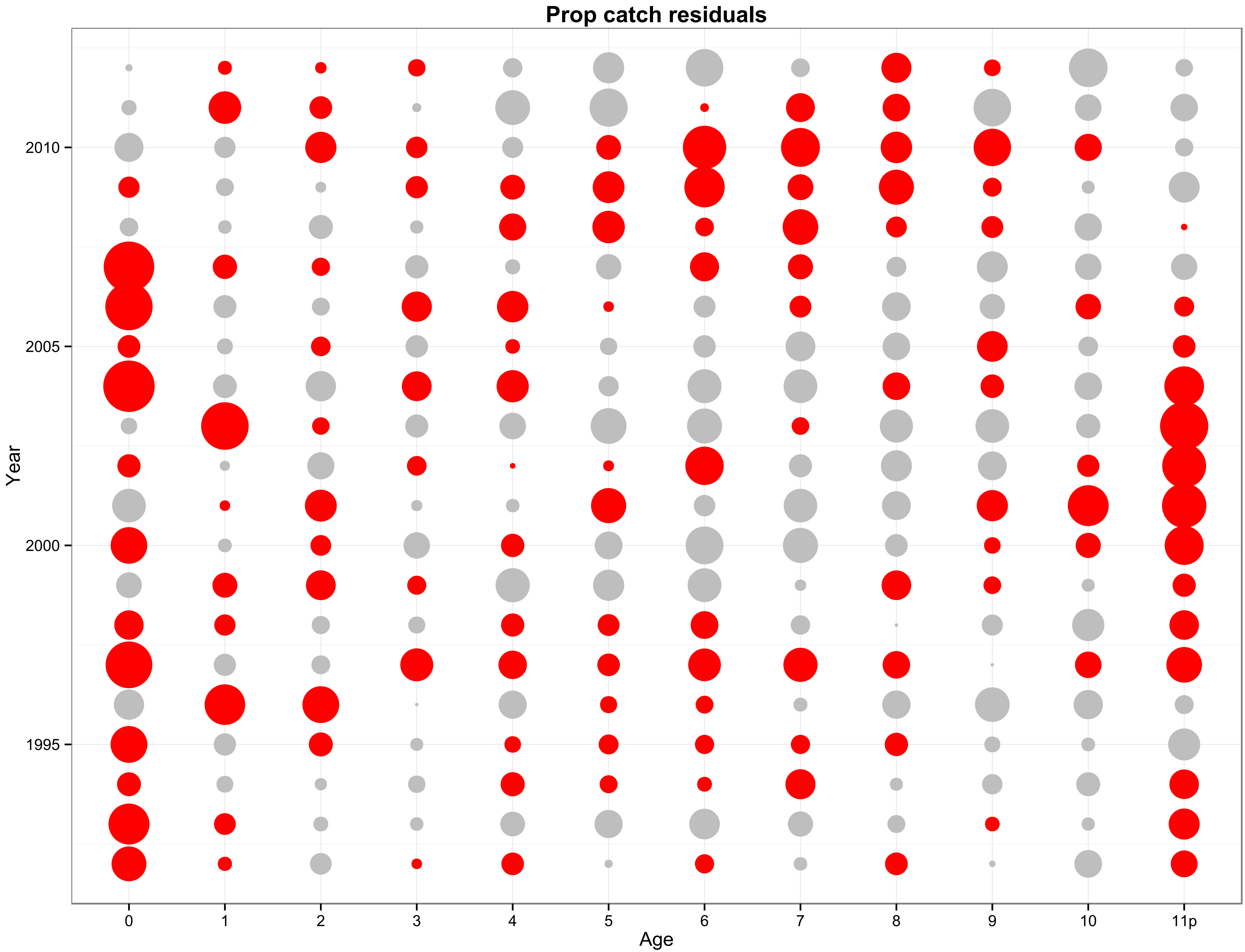
2005
2006
2007
2008
2009
2010
2011
prop_survey
0.0
0.2
0.4
0.6
0.8
1 2 3 4 5 6 7 8 9 10 11p
Age


Prop catch residuals
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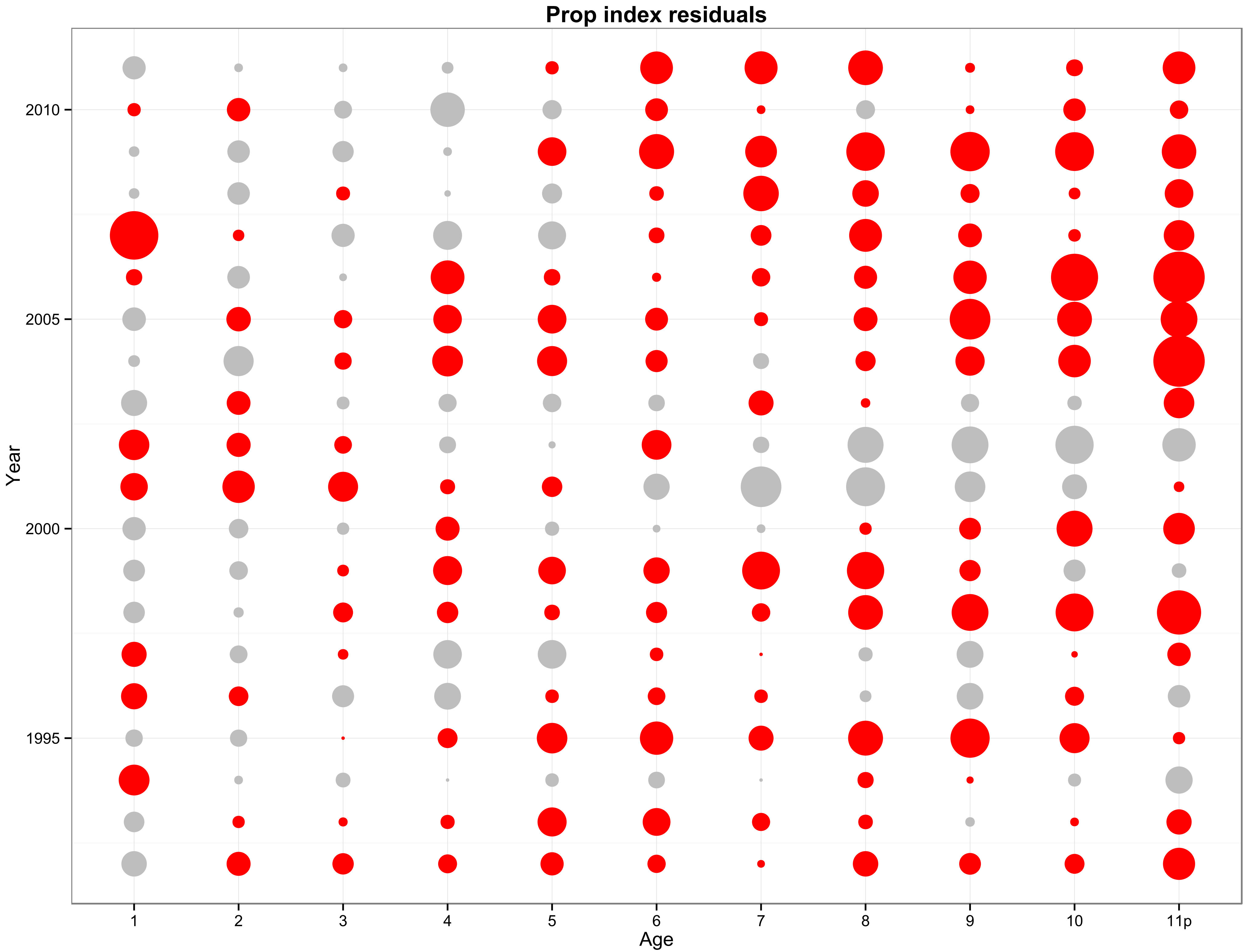

Prop index residuals
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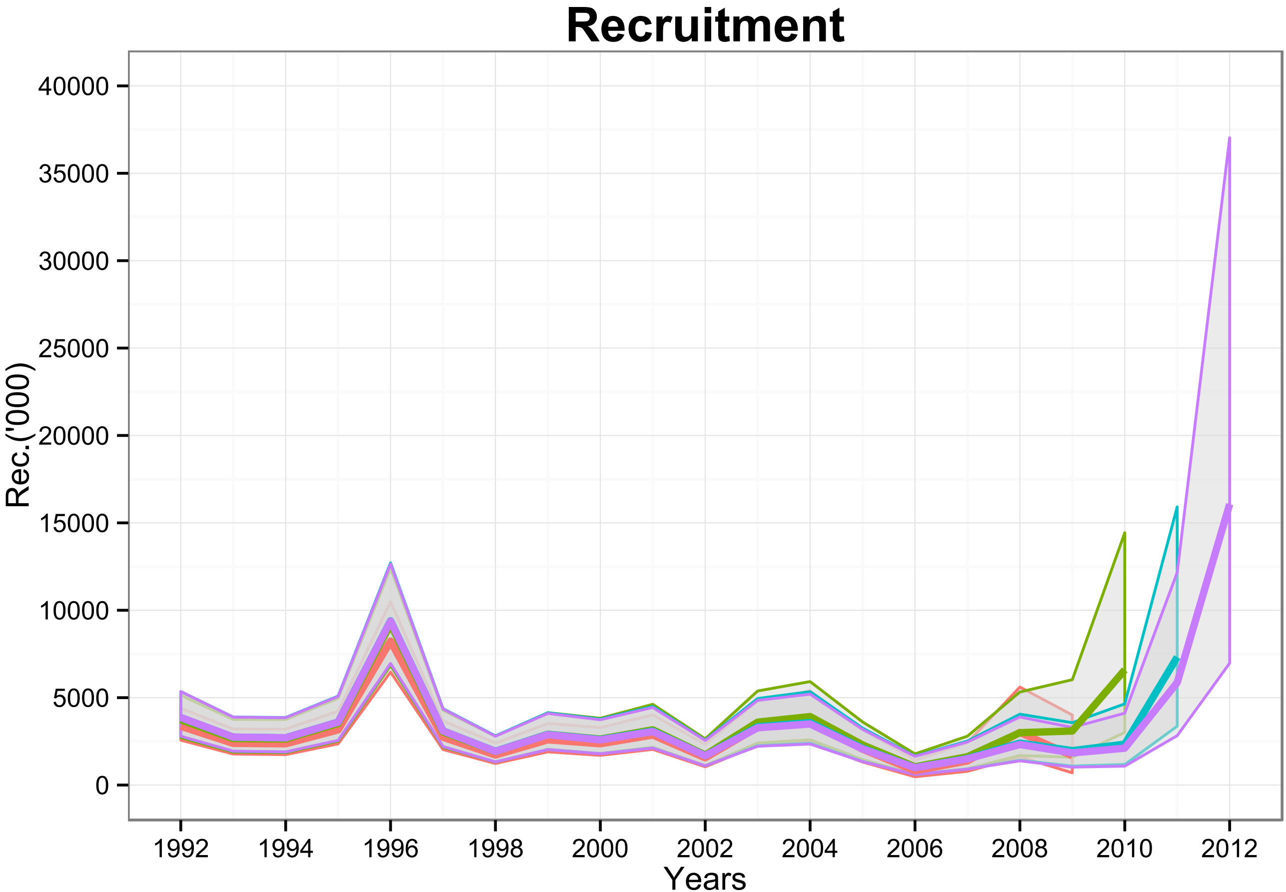
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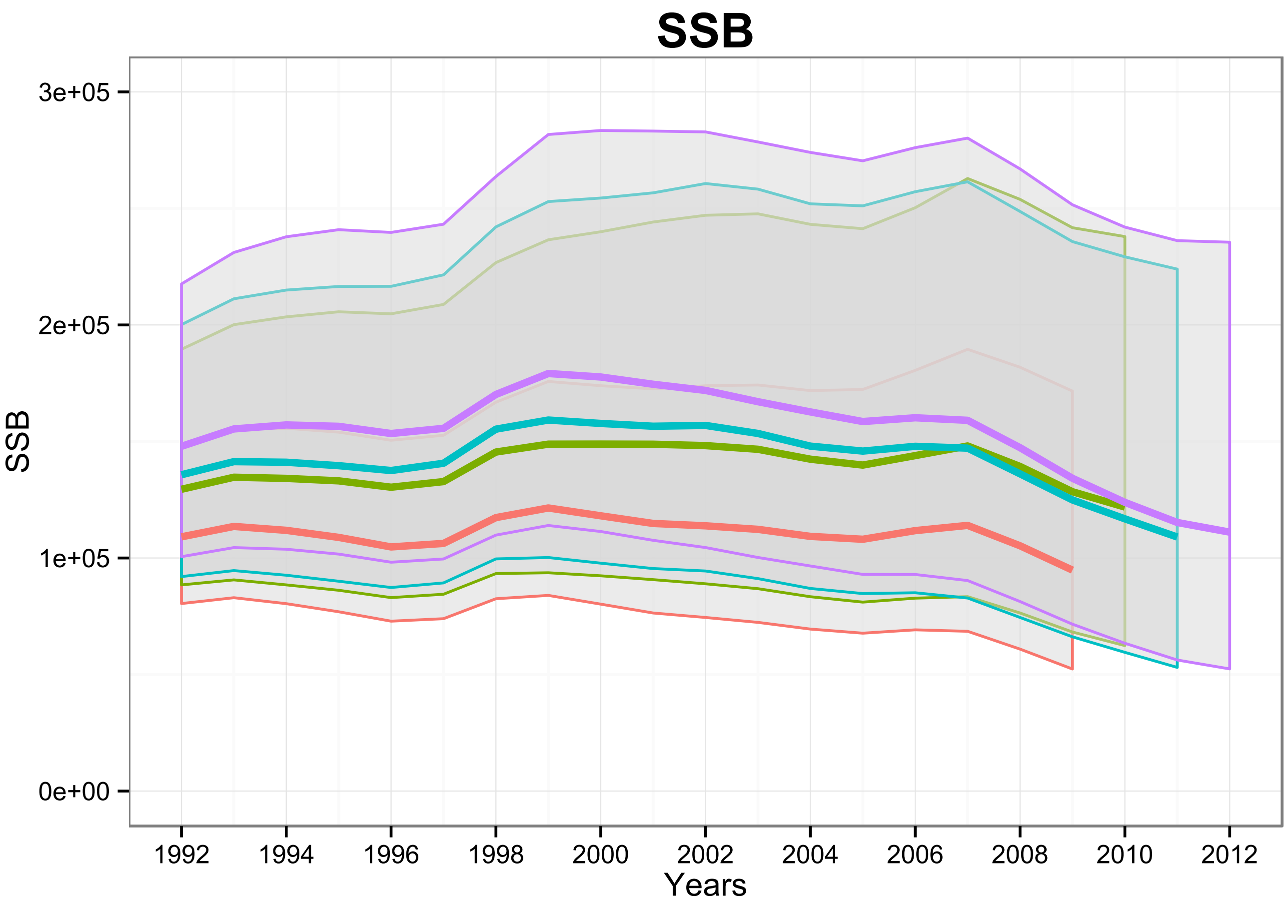

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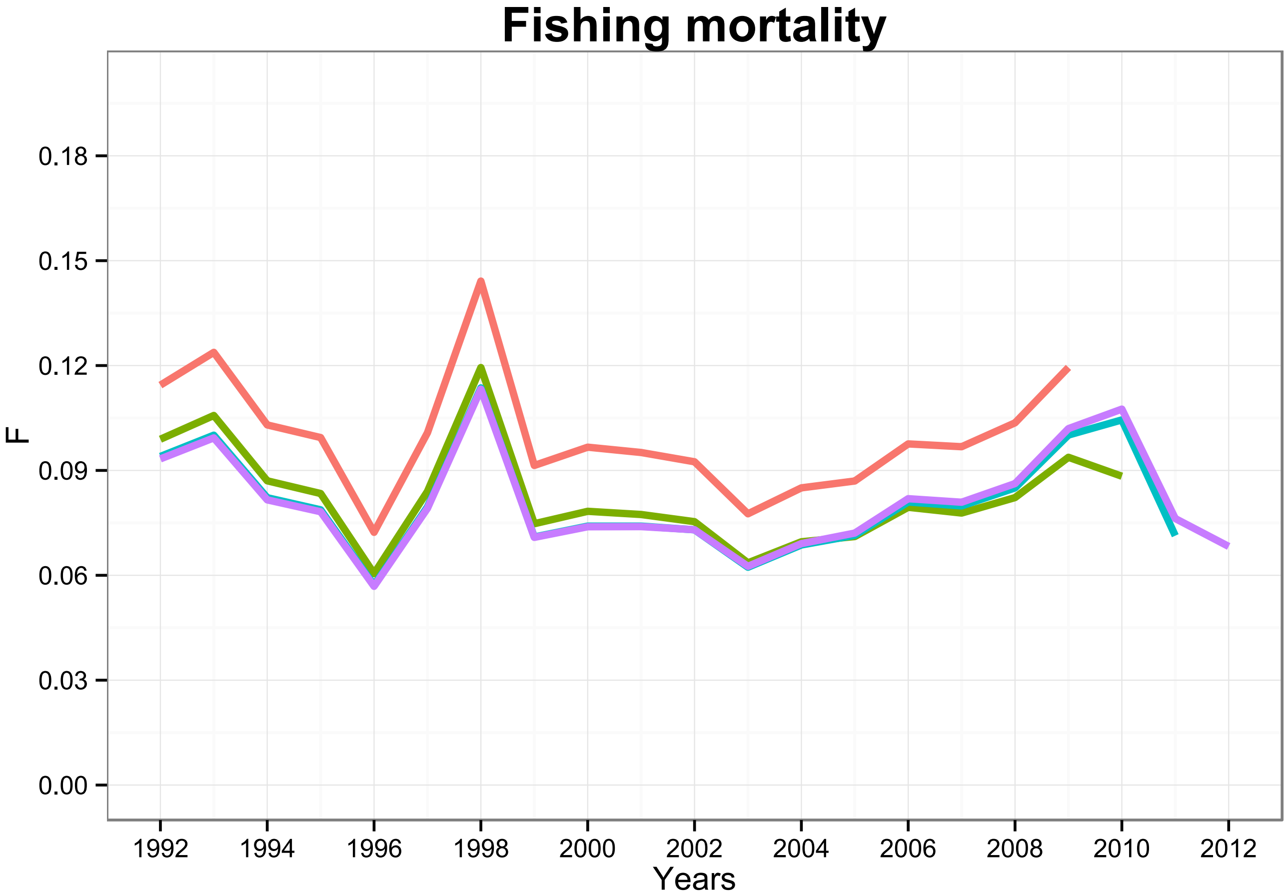
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9 Jack Mackerel T. picturatus in the waters of the Azores

9.1 General Jack Mackerel

The jack mackerel, Trachurus picturatus Bowdich, 1825 (Carangidae) is a pelagic fish species distributed through the Northeast Atlantic, Eastern Central Atlantic, Mediterranean and the Black Sea. Its characteristic habitat includes the neritic zones of islands shelves, banks and seamounts (Smith-Vaniz, 1986). It has a schooling behaviour and prey mainly on crustaceans, being common in the islands of Madeira, Azores, and Canaries and Portuguese continental waters.

No studies specifically addressing the existence of distinct populations in the distribution range of this species have been attempted so far. Some studies on growth and biological characteristics from Madeira and Azores (Isidro, 1990; Jesus, 1992; Gouveia, 1993) indicated differences in growth rates, age at first maturity and reproductive season, which could be correlated with water temperatures. According to Shaboneyev & Ryazantseva (1977) biological differences seem to exist between individuals from the Azores compared with those from the Canary islands, and adjacent waters of western Europe. Although there is a lack of morphometric studies on T. picturatus, some variation was found in some of the meristic characteristics in individuals collected from different geographic areas, concerning the soft spines of the second dorsal fin (Shaboneyev & Kotlyar 1979; Smith-Vaniz, 1986). However, meristic characters are heavily influenced by the environmental conditions experienced by the fish while in the larval stages, therefore in the case of migratory oceanic species, such as T. picturatus, are usually considered of reduced utility for the identification of stock units.

A number of studies have successfully used parasites as biological markers. Gaevskaya and Kovaleva (1985) conducted a survey of the parasites of T. picturatus from the Azores and western Sahara. Their study identified a number of protozoan and helminth parasites showing differences in prevalence. The myxosporean Kudoa nova was found in samples from the western Sahara, but not from banks of the Azores archipelago. Similarly, some species of digeneans (Platyhelminths: Digenea) found in the banks of the Azores, were not observed in the samples from the western Sahara and vice-versa. The apicomplexan, Goussia cruciata which is common in T. picturatus from the Mediterranean (Kalfa-Papaioannou & Athanassopoulou-Raptopoulou, 1984) and more recently from Madeira waters (Gonçalves, 1996), was not found in the Azores or from the western Sahara. These variations in the occurrence of parasites could be indicative of the existence of different populations of T. picturatus. Further studies concentrating the occurrence of helminth parasites indicate some differences in both species diversity and parasitic infections levels (Costa et al. 2000, 2003).

The jack mackerel is an economically important resource, especially in the Macaronesian islands of Azores and Madeira, where is the main pelagic fish species being caught in the local fisheries. The landings of this species in the Portuguese mainland have suffered strong fluctuations, which may be related, at least partially to fluctuations in abundance or availability. From 2005 to 2007 the landings have tripled, being 2007 the year with the highest landings recorded. In the Azores archipelago the landings have also fluctuated, while in Madeira the average of the landings from 1986 to 1991 was three times higher than the average landings from 1992 to 2007. The hypothesis that the fluctuations in landings can be due to changes in availability or abundance, and not just by changes in fishing effort, is supported for the Portuguese mainland by the observation of fluctuations in the abundance indices obtained from research surveys.

9.2 ACOM Advice Applicable to 2010

No advice has ever been given to this stock.

9.3 The fishery in 2012

The jack mackerel (*Trachurus picturatus*) is the only species of genus *Trachurus* that occurs in the Azores, where it's exploited by different fleets and métiers. The main catches are those of the artisanal fleet that operates with several types of surface nets, the most important being the purse seines. Purse seines are also used by the tuna bait boat fleet, which targets the jack mackerel as live bait for tuna. The artisanal purse seine fleet that operates in the vicinity of the islands (Figure 9.3.1) with purse seines is responsible for the main share of the catches and is composed by small open deck vessels, mostly with less than 12 meters of length overall.

The demersal fleet, composed of vessels using longlines and a variety of handlines catch jack mackerel, mostly as bycatch, in the multi-specific demersal fishery. Only a portion of those catches are landed, a large percentage is used as bait or discarded at sea. In recent years the amounts of jack mackerel used as bait in the demersal fishery have been increasing. The main fishing areas of the bottom longline fleet are located in the Azores seamounts but also close to shore (Figure 9.3.2). One other important component of the surface fishery are the catches made by the tuna baitboat fleet that also uses purse seines to catches jack mackerel to be used as live bait for tuna. Their catches are estimated from data collected from logbooks and by an observer program. The variability of the catches from these fleets reflects also the availability of tuna in the Azorean area in each year. The geographical distribution of the catches of jack mackerel by tuna baitboat fleet in the Azores is showed in figure 9.3.2. The jack mackerel is also a very popular species among the recreational fisherman that fish along the coast of all islands.

During the past 5 years, the total estimated catches of jack mackerel in the Azores are around 1800 tonnes (figure 9.3.3. and table 9.3.1) while the landings in recent years average 1000 tonnes. The horse mackerel is mostly landed by the artisanal fleet, using purse seines and their catches have been maintained at a relatively stable level since 1990, by an auto regulation adopted by the fisherman associations due to market restrictions. This stability of the catches is mostly observed in S. Miguel Island, where around 75% of the annual catches occur (figure 9.3.4). Continuous reductions in the demands from the consumers lead to the catch limits auto adopted by the fleet, which explains the reduction observed in the catches along the recent years.

In 2012 an important reduction was observed in the catches of all fishing gears, but particularly for those targeting the juveniles, such as the artisanal purse seine fleet and the tuna baitboats fleet. In the case of the artisanal seiners the reduction observed was close to 50%. Concerning the longliners, the reduction observed in 2012 is mostly related to the practice of using the jack mackerel for bait, since their market price is too low.

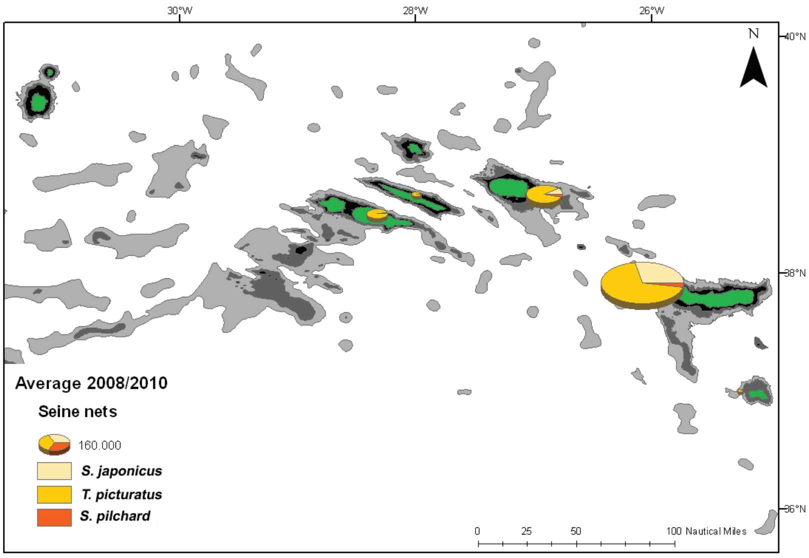

Figure 9.3.1. Geographical distribution of the catches of small pelagics by the artisanal purse seine fleet in the Azores (average 2008-2010).

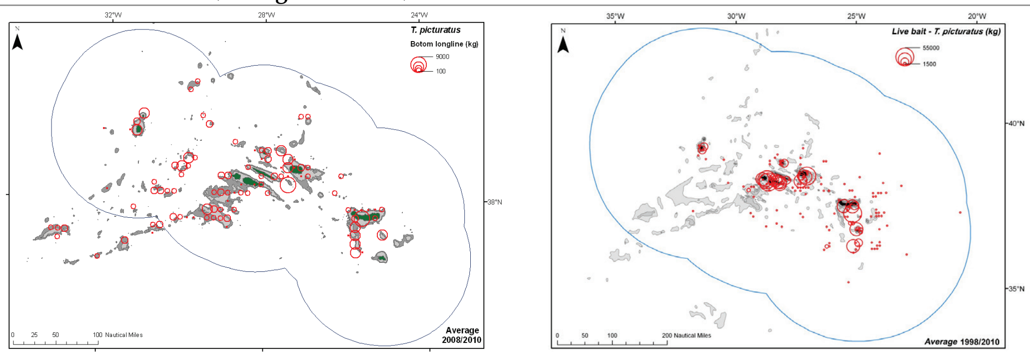

Figure 9.3.2. Geographical distribution of the catches of horse mackerel by the longline fleet (left panel) and the tuna baitboat fleet (right panel) in the Azores (average 2008-2010).

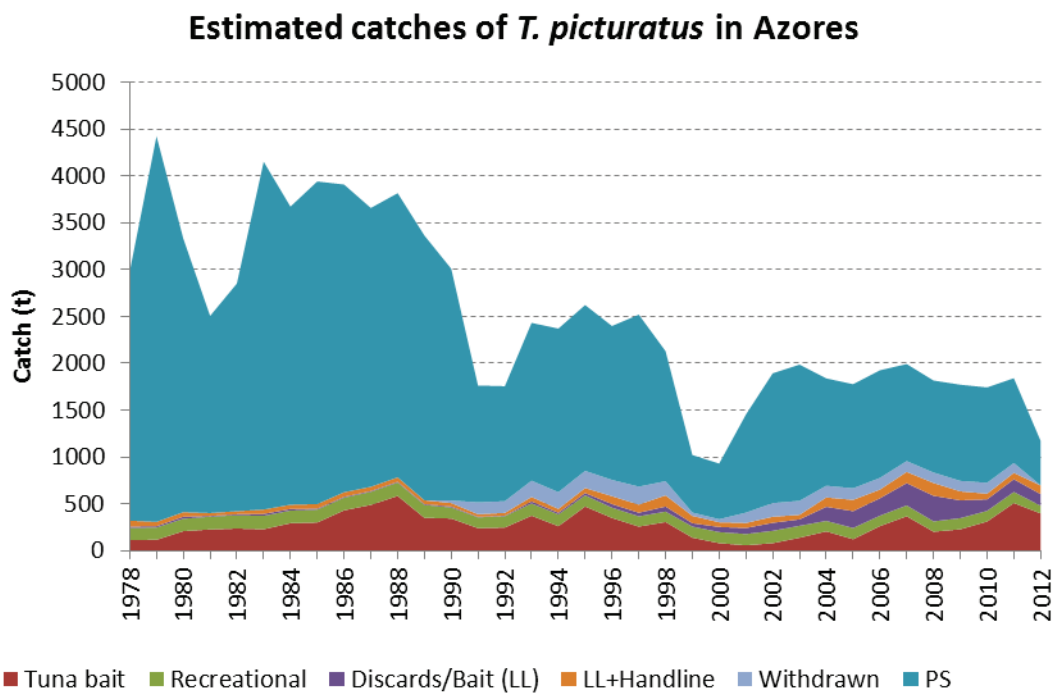

Figure 9.3.3. - Estimated catches of jack mackerel (*T. picturatus*) in the Azores (ICES area X) from 1978 to 2012.

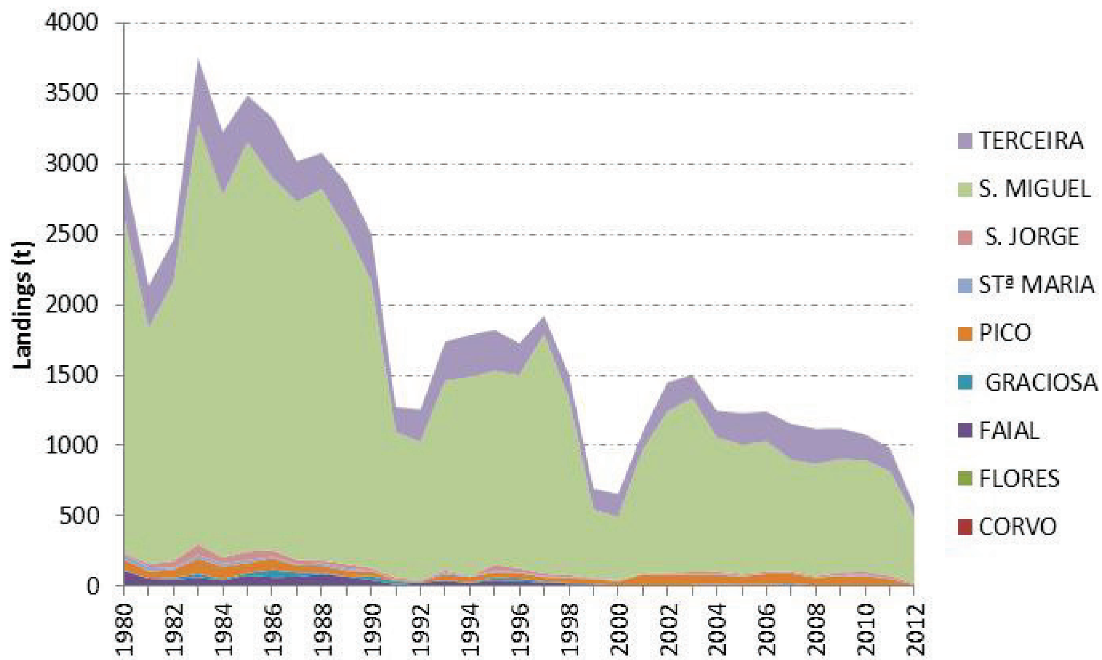

Figure 9.3.4. Landings of jack mackerel in the Azores, by island (1980-2012).

9.3.1 Fishing Fleets in 2012

The jack mackerel is mostly landed by the artisanal fleet, using purse seines. The fleet segments that use hand lines and bottom longlines also catches jack mackerel, but the catches are only partially landed, since an important part of their catches is used for bait in the demersal species fishery. The catches made by the tuna bait boat fleet, for use as live bait for tuna, are not landed. Those catches are estimated by the tuna observer program and from information in the logbooks.

The artisanal purse seines fleet is composed by small open deck vessels, mostly with less than 12 meters of length overall. The composition of this fleet, classified in three length categories (LOA) as showed in figure 9.3.5, presented a sharp decrease in the number of vessels during the exploitation period considered and has remained stable in the recent years. The contribution to the landings of the vessels of each size category is showed in figure 9.3.6

The fleet segments that use hand lines and bottom longlines also catches jack mackerel, but the catches are only partially landed, since an important part of their catches is used for bait in the demersal fishery or discarded. Figure 9.3.7 shows the percentage of jack mackerel discarded or used as bait by the longline fleet, from 2004 to 2011, representing an average of 68% since 2007. The catches also made with purse seines by the tuna baitboat fleet, for use as live bait for tuna, are not landed. Two sources of data are used to estimate the jack mackerel catches from the tuna fleet: information from the logbooks and by the tuna observer program. The tuna observer program targets a minimum annual coverage of 50% of the tuna trips and of the tuna catches.

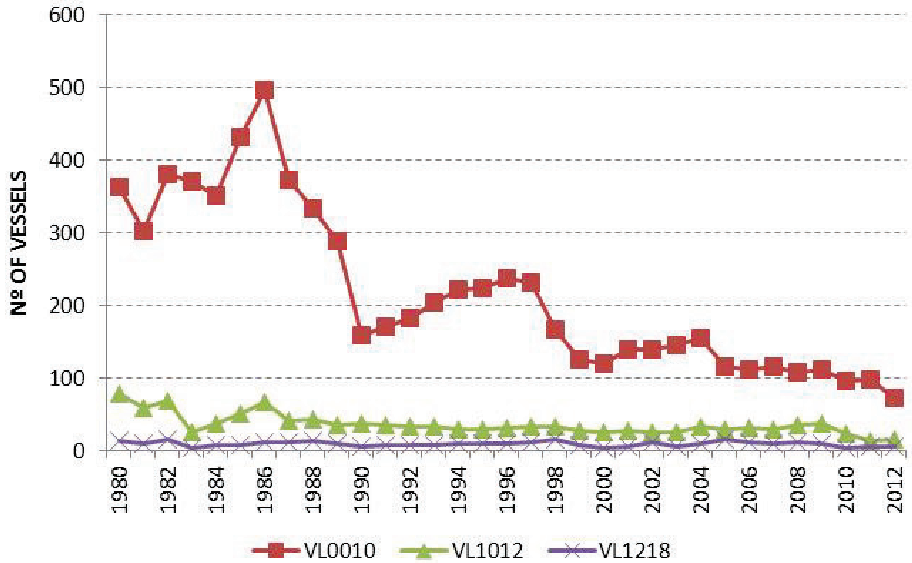

Figure 9.3.5. Number of vessels, by size category, using purse seines for jack mackerel in the Azores, from 1890 to 2012.

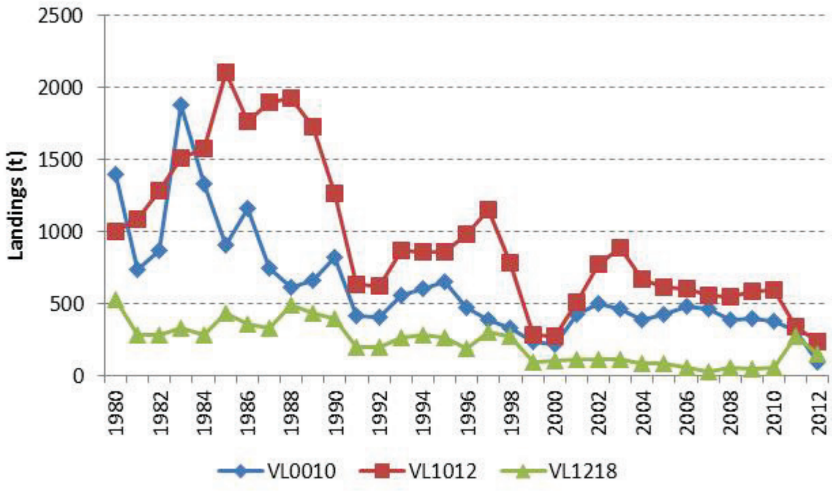

Figure 9.3.6. Landings of jack mackerel by size category of vessels using purse seines in the Azores, from 1890 to 2012

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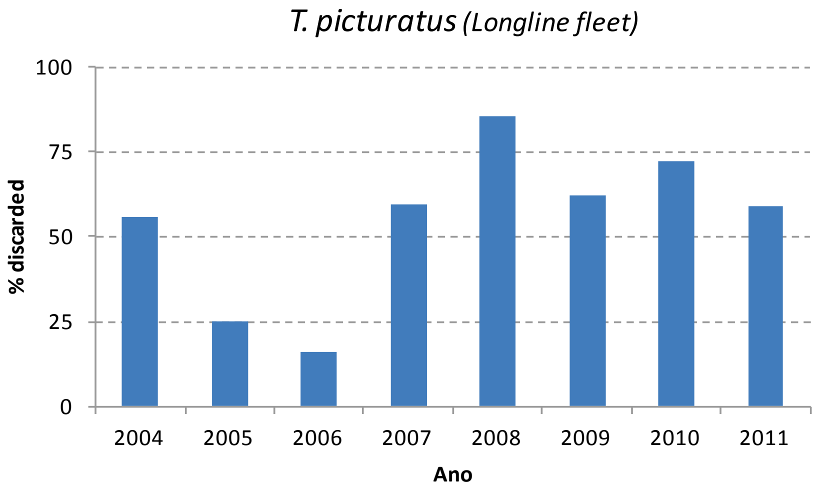

Figure 9.3.7. Percentage of the catches of jack mackerel discarded or used as bait by the Azores longline fleet.

9.3.2 Catches

After a period of large catches until the end of the 1980's, changes in the local markets lead to a strong reduction in the catches. This reduction was also accompanied by a sharp decrease in the small pelagics fleet (figure 9.3.5). The catches of this fleet had since been maintained at a low level due a voluntary auto regulation adopted by the fisherman associations, each vessel can only land a maximum of 400kg per day. The estimated catches of jack mackerel by fishery, from 1978 to 2012, is presented in Table 9.3.1 and Figure 9.3.3.

Table 9.3.1. Estimated catches of jack mackerel (*T. picturatus*) by fishery, in the Azores (ICES area X) from 1978 to 2012.

Year	Tuna bait	Recreational	Discards/Bait (LL)	Withdrawn	PS	LL+Hand	Total
1978	115	129	15	0	2657	78	2995
1979	118	130	15	0	4114	61	4439
1980	210	132	22	0	2920	70	3354
1981	229	135	9	0	2104	39	2516
1982	239	142	10	0	2429	43	2862
1983	231	142	21	0	3711	67	4172
1984	295	135	17	0	3180	62	3689
1985	303	136	11	0	3442	60	3952
1986	433	135	9	0	3282	58	3918
1987	491	139	8	0	2974	53	3666
1988	586	143	8	0	3032	55	3824
1989	352	138	9	0	2824	50	3373
1990	345	117	11	27	2472	48	3021
1991	242	115	6	127	1247	33	1770
1992	249	121	6	126	1226	35	1762
1993	375	130	22	173	1684	70	2454
1994	264	125	18	179	1745	59	2390
1995	474	119	24	182	1769	79	2648
1996	351	110	38	173	1642	123	2437
1997	259	110	39	192	1836	124	2559
1998	308	111	54	151	1387	174	2185
1999	141	119	36	35	614	114	1058
2000	83	117	55	32	594	106	987
2001	59	121	64	110	1047	118	1520
2002	82	132	85	145	1385	150	1979
2003	140	128	68	150	1453	116	2055
2004	208	111	150	125	1146	251	1991
2005	124	120	180	123	1110	301	1959
2006	264	111	186	124	1149	279	2113
2007	370	115	239	115	1035	358	2232
2008	205	110	273	111	982	410	2091
2009	230	119	190	112	1026	286	1964
2010	313	114	122	116	1017	184	1866
2011	510	118	136	105	904	204	1978
2012	399	42	124	NA	474	92	1131

9.3.3 Effort and catch per unit effort

The data on catch and effort collected includes fleet characteristics, quantities caught and landed, fishing effort, gears used and fishing grounds, that are obtained through interviews to the fisherman at the landing sites, logbooks and by observers on board the fishing vessels. Two observer programs are currently operating, one on the demersal logline fleet, collecting detailed information on fishing operations and the amount and size composition of the catches, including data on discards and one other observer program that collects information on board of the tuna vessels, including the fishing for bait species, among which the horse mackerel is the major species.

Standardized CPUE are available for 3 of the fisheries catching jack mackerel, the small purse seine fleet, the tuna baitboat catches of jack mackerel for use as live bait for tuna and the catches of the bottom longline fleet. The standardized CPUE series were updated for the small purse seine fleet and the baitboat catches of jack mackerel for use as live bait for tuna, up to 2012. The CPUE series for the longliners was not updated.

9.3.3.1 Standardized CPUE for small purse seines

Large purse seines (over 12 m LOA) show higher nominal catch rates of horse mackerel, and were observed also higher catch rates in Sao Miguel Island. There were no major differences in catch rates by season.

Standardized CPUE series for jack mackerel are shown in Table 9..3.2 and figure 9.3.8. Estimated coefficients of variation average 18%. The standardized CPUE series show that the relative abundance of horse mackerel varied in the early part of the series (1980-98) followed by a large increase in 1998/99, followed by an stable trend since 1993 in the latest years of the series. A decreasing trend in the index of abundance is observed for the two most recent years in the small purse seine fishery. Although, in recent years the average catch rates are slight below compare to the earlier years.

Table 9.3.2. Estimated standardized relative index of abundance for jack mackerel from the Azorean small purse seine fishery fleet.

Year	N Obs	Std Cpue	Stnd. Error	95% Low	95%Up	Nominal Cpue
1980	933	1.178	7.779	1.200	1.159	1.173
1981	1030	1.142	7.417	1.164	1.122	1.183
1982	1181	1.114	6.964	1.139	1.093	1.115
1983	1067	1.103	8.048	1.117	1.090	0.943
1984	1170	1.104	7.105	1.127	1.085	0.993
1985	1404	1.211	6.393	1.248	1.179	1.193
1986	1626	1.164	5.953	1.201	1.132	1.098
1987	1316	1.169	6.555	1.201	1.141	1.155
1988	1155	2.453	7.196	2.577	2.346	2.586
1989	1022	2.566	7.602	2.695	2.453	2.719
1990	651	1.141	9.678	1.144	1.138	1.318
1991	436	0.919	13.835	0.869	0.962	1.113
1992						
1993	1087	0.831	7.336	0.831	0.831	0.836
1994	1102	0.788	7.230	0.785	0.790	0.775
1995	1136	0.769	7.051	0.766	0.771	0.722
1996	1047	0.861	7.388	0.863	0.860	0.781
1997	849	0.907	8.207	0.905	0.909	0.922
1998	707	0.840	9.012	0.826	0.852	0.866
1999	508	0.736	10.870	0.698	0.769	0.710
2000	456	0.759	11.570	0.717	0.796	0.699
2001	487	0.984	10.808	0.966	1.001	0.963

2002	648	0.927	9.426	0.916	0.937	0.940
2003	702	0.941	9.459	0.930	0.949	0.906
2004	723	0.748	8.967	0.728	0.766	0.711
2005	651	0.786	9.434	0.764	0.805	0.792
2006	673	0.773	9.240	0.752	0.791	0.779
2007	688	0.736	9.044	0.714	0.756	0.724
2008	600	0.729	9.801	0.700	0.754	0.773
2009	678	0.705	9.165	0.679	0.727	0.708
2010	662	0.739	9.332	0.715	0.760	0.663
2011	589	0.651	9.899	0.615	0.682	0.624
2012	421	0.526	13.556	0.449	0.593	0.516

In Figure 9.3.8, the standardized cpue (kg/day fishing) is presented for the juvenile stock, caught by the small purse seine fleet.

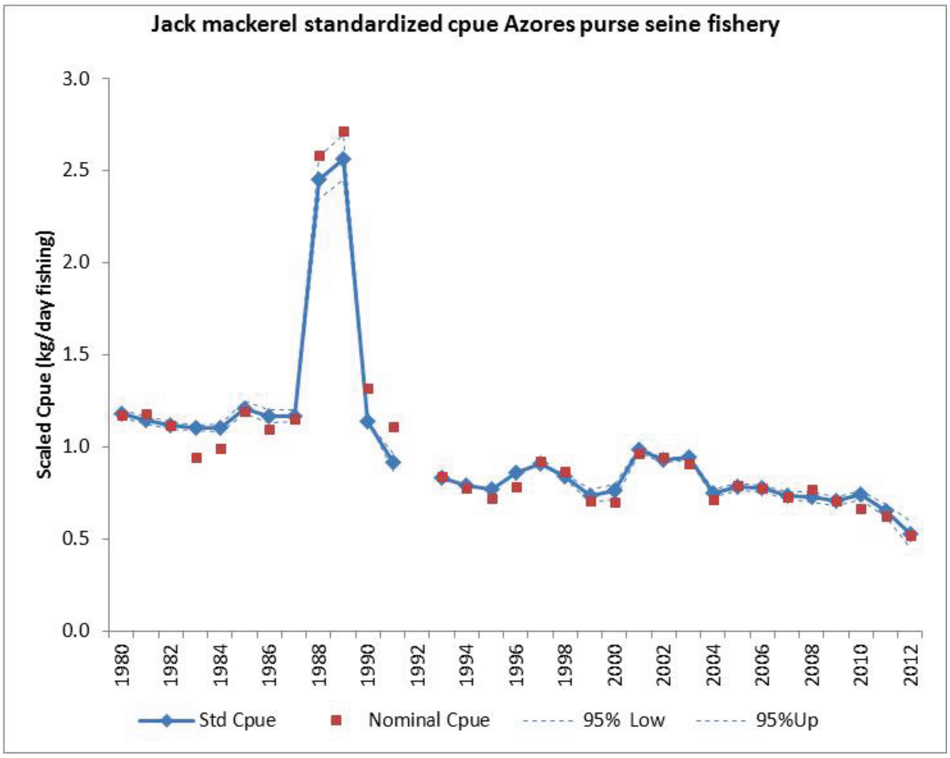

Figure 9.3.8 - Standardized (solid line) and nominal CPUE for jack mackerel from the Azores small purse seine fishery 1980 – 2012. Broken lines indicated 95% confidence intervals

9.3.3.2 Standardized CPUE for tuna baitboat fleet

Standardized CPUE series for jack mackerel from the Azorean bait catch of the tuna baitboat fishery are shown in Table 9.3.3 and figure 9.3.9. Estimated coefficients of variation average 46%. The standardized CPUE series show that the relative abundance of horse mackerel varied in the early part of the series (1980-98) followed by an increase since 2006. In recent years the average catch rates used to be above the overall average, but in 2012 the index of abundance is lower than what was observed in the past 4 year in this fishery.

Table 9.3.3. Estimated standardized relative index of abundance for jack mackerel from the Azorean tuna baitboat fishery fleet.

Year	N Obs	Std Cpue	Stnd. Error	95% Low	95%Up	Nominal Cpue
1998	100	270.125	23.732	223.612	316.638	248.844
1999	89	217.180	24.140	169.868	264.493	169.168
2000	66	210.815	27.898	156.137	265.494	178.173
2001	33	244.799	36.581	173.101	316.497	243.887
2002	22	280.809	43.424	195.700	365.918	288.281
2003	25	218.452	40.758	138.567	298.337	181.627
2004	36	217.317	35.158	148.408	286.225	201.615
2005	42	217.022	32.964	152.413	281.631	187.989
2006	34	255.399	35.666	185.495	325.304	232.035
2007	73	218.321	26.481	166.419	270.222	174.515
2008	56	296.564	29.119	239.493	353.636	279.144
2009	56	307.170	28.394	251.519	362.822	314.614
2010	85	260.302	24.594	212.099	308.505	237.621
2011	106	291.999	22.946	247.025	336.973	288.330
2012	127	242.066	18.778	205.261	278.870	238.338

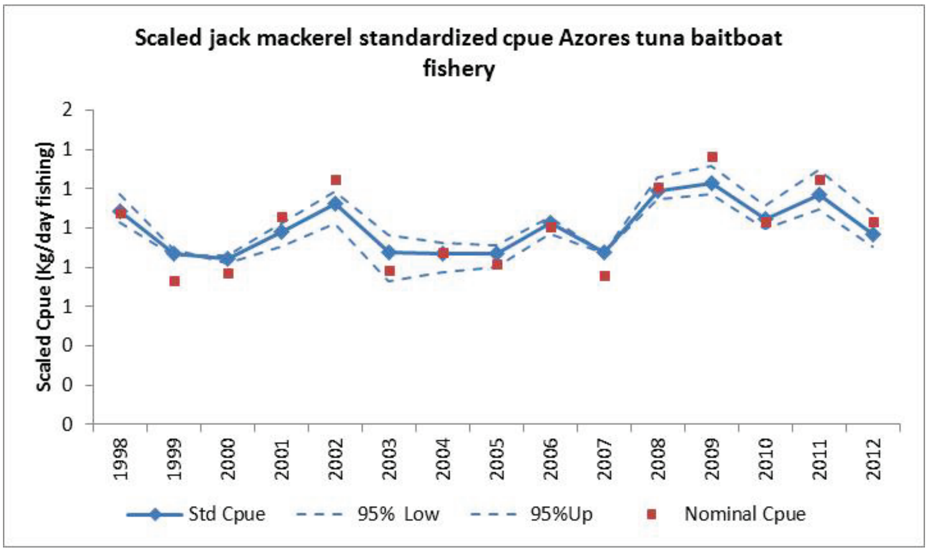

Figure 9.3.9. Scaled nominal and standardized catch rates of horse mackerel from the Azorean baitboat tuna fishery 1998-2012.

9.3.3.3 Standardized CPUE for longline fleet

Standardized CPUE series for jack mackerel from the Azorean longline fishery are shown in Table 9.3.4 and figure 9.3.10, for the period 1990 to 2010. Estimated coefficients of variation are large, as indicated by the wide confidence intervals. The standardized CPUE series show that the relative abundance of horse mackerel varied in the early part of the series (1990-98) followed by an increase from 2000 until 2008 with the highest catch rates in 2008, followed by a decline in the latest years of the series.

The decline observed in the latest years can be explained by the current practice of the bottom longline fleet to land only part of the catches of jack mackerel and discards and retains on board an important part of the fish caught to be used for bait in the demersal fishery (figure 9.3.7). This practice is explained by the low market value of horse mackerel. Figure 9.3.7 shows the percentage of horse mackerel caught and discarded or used as bait by the longline fleet, from 2004 to 2010, representing an average of 68% since 2007.

Table 9.3.4. Estimated standardized relative index of abundance for horse mackerel from the Azorean longline fishery fleet.

Year	N obs	Nominal Cpue	Standard CPUE	95 % Low CI	95% Upp CI	CV	std error	Nominal	Estimated
1990	36	0.187	0.173	0.04	0.79	88%	0.249	0.61	0.28
1991	95	0.433	0.281	0.06	1.33	91%	0.419	1.42	0.46
1992	85	1.764	1.531	0.39	6.03	77%	1.934	5.77	2.50
1993	210	1.046	0.679	0.20	2.32	68%	0.751	3.42	1.11
1994	141	0.321	0.500	0.16	1.56	62%	0.504	1.05	0.82
1995	198	0.457	0.372	0.11	1.20	64%	0.389	1.49	0.61
1996	275	1.201	1.870	0.70	4.98	52%	1.587	3.93	3.05
1997	249	0.532	0.703	0.23	2.17	61%	0.701	1.74	1.15
1998	188	0.545	0.638	0.17	2.36	73%	0.760	1.78	1.04
1999	69	0.620	0.543	0.12	2.48	88%	0.783	2.03	0.89
2000	97	0.230	0.287	0.07	1.17	80%	0.375	0.75	0.47
2001	38	0.416	0.727	0.24	2.20	60%	0.712	1.36	1.19
2002	29	0.715	1.039	0.33	3.22	61%	1.040	2.34	1.69
2003	45	1.233	1.693	0.49	5.89	69%	1.902	4.03	2.76
2004	70	0.721	1.654	0.63	4.33	51%	1.375	2.36	2.70
2005	77	1.175	0.617	0.20	1.90	61%	0.613	3.85	1.01
2006	47	1.889	1.290	0.40	4.13	63%	1.334	6.18	2.10
2007	40	1.523	1.433	0.46	4.49	62%	1.451	4.98	2.34
2008	77	3.670	2.700	1.03	7.10	51%	2.259	12.01	4.40
2009	88	1.506	1.224	0.38	3.96	64%	1.282	4.93	2.00
2010	129	0.815	1.049	0.38	2.91	55%	0.933	2.67	1.71

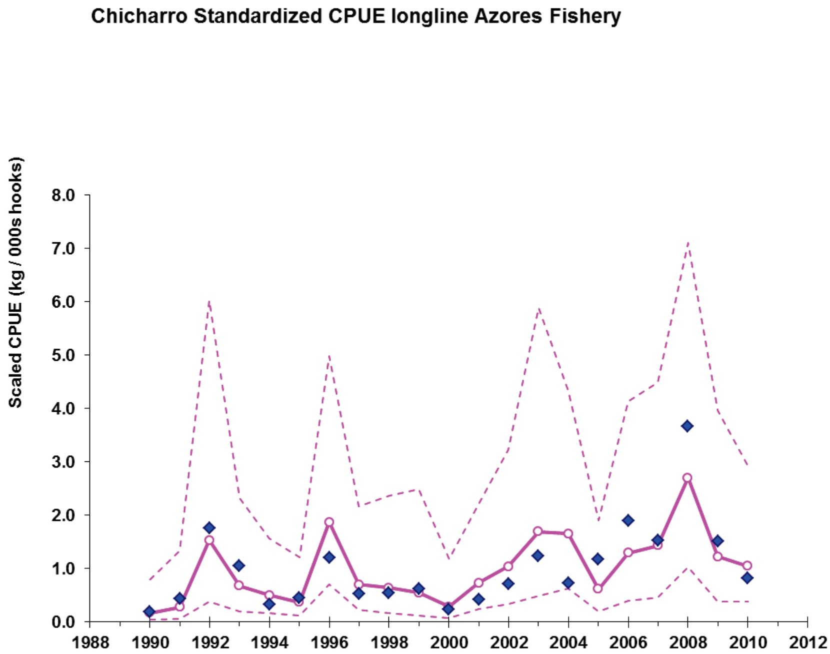

Figure 9.3.10. Standardized relative catch rates of jack mackerel from the longline Azores fishery. Solid line represents standardized index, broken lines the estimated 90% Confidence bounds, and the filled diamonds the nominal CPUEs.

9.3.4 Catches by length

Size frequencies for the jack mackerel caught in the Azores are available since 1980. In Figure 9.3.11, is presented the size distribution of the landings (catch at size) for the years 2001 to 2010. The size distribution (catch at size) of the landings of jack mackerel caught by two of the main métiers involved in the fishery, artisanal purse seiners and longliners, is presented in Figure 9.3.12.

The two main fisheries target on different size categories, the surface fleets catches the juvenile fraction of the population while the longliners target the adult stock.

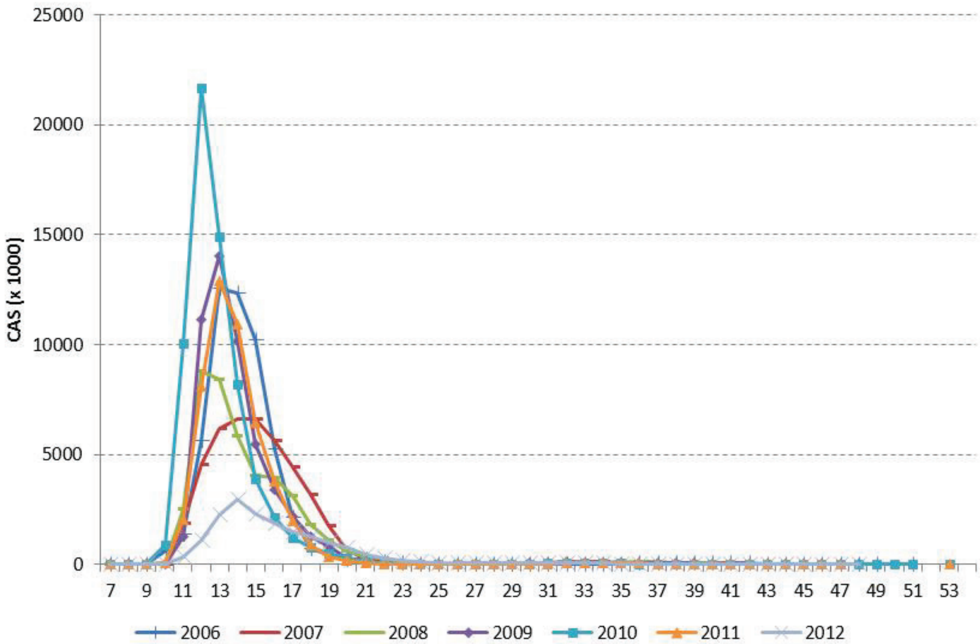

Figure 9.3.11 – Annual size frequencies of the catches of jack mackerel (*T. picturatus*) in the Azores, from 2006 to 2012.

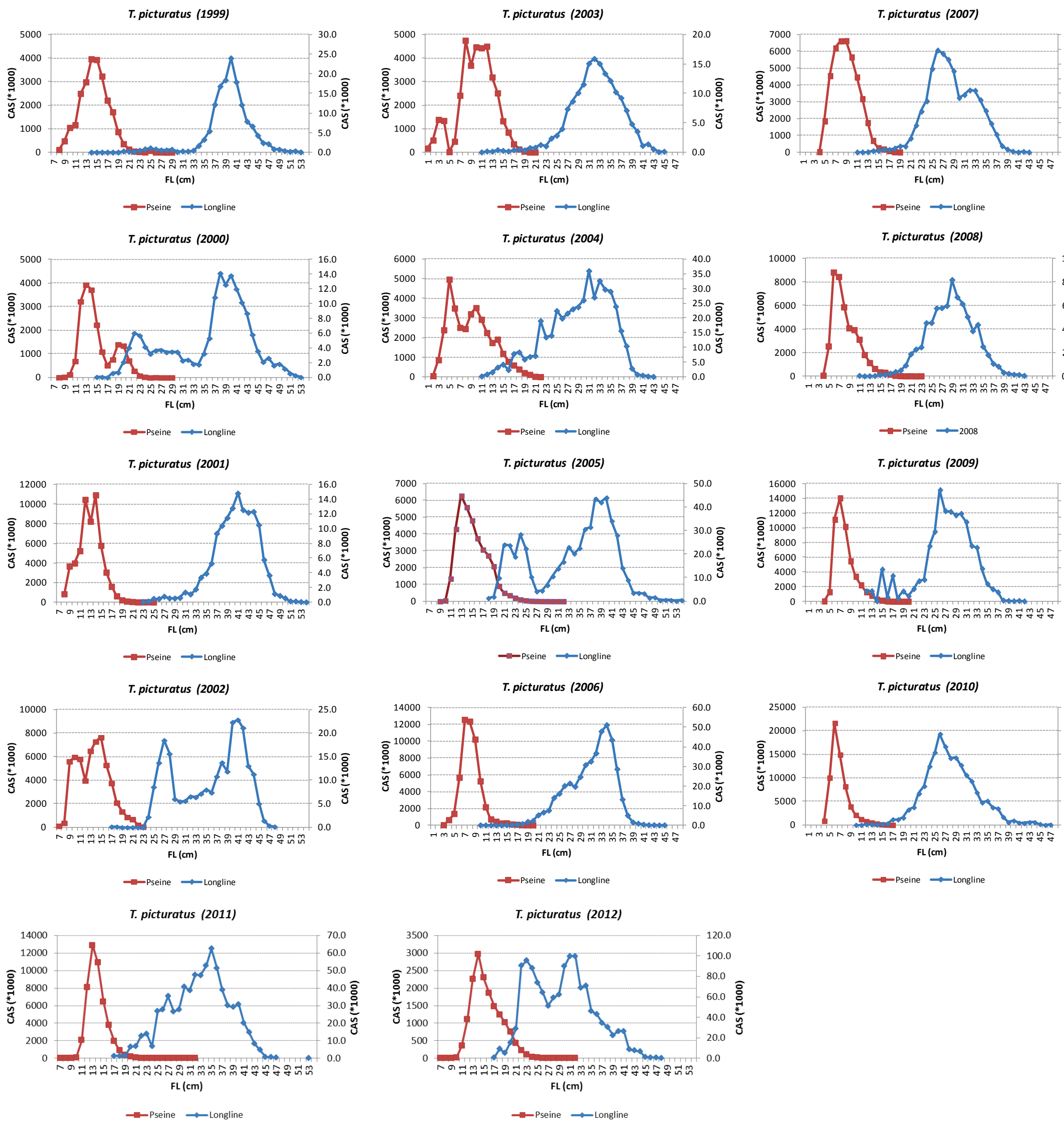

Figure 9.3.12 – Annual size frequencies of jack mackerel (*T. picturatus*) caught in the Azores by purse seine and longlines, from 1999 to 2012.

9.3.5 Mean weights in the catch

The analysis of the sizes caught shows stability along the analysed period, which is also confirmed by the stability in the average weights (figure 9.3.13) of the fish caught by the different métiers involved in the fishery.

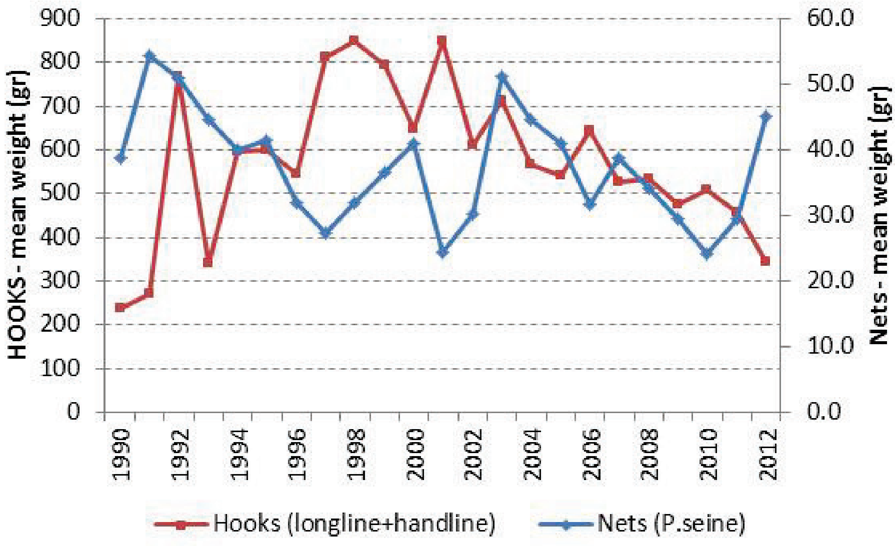

Figure 9.3.13 - Annual mean weights of landings of the Jack mackerel caught in the Azores by different métiers.

9.3.6 Catch at age

The conversion of the catch at size to catch at age of the jack mackerel caught in the Azores by the two main metiers, purse seines and hook and line, shows a distribution of the catches characteristic of each metier, the purse seines catching mostly juvenile fish, ages 1 and 2) and the longliners catching the adult fish (figures 9.3.14. and 9.3.15).

In 2012 a change in the age composition of the catch is noted for age 1 that shows a decrease to 76% when compared with the 2009-2011 average of 96%. This change in the age composition of the catches in 2012 is probably due to recruitment failure of age 1 fish. An opposite change occurred for age 2 catches that increased to 23.3% when compared to the 3.7% average in 2009-2011 (figure 933.14).

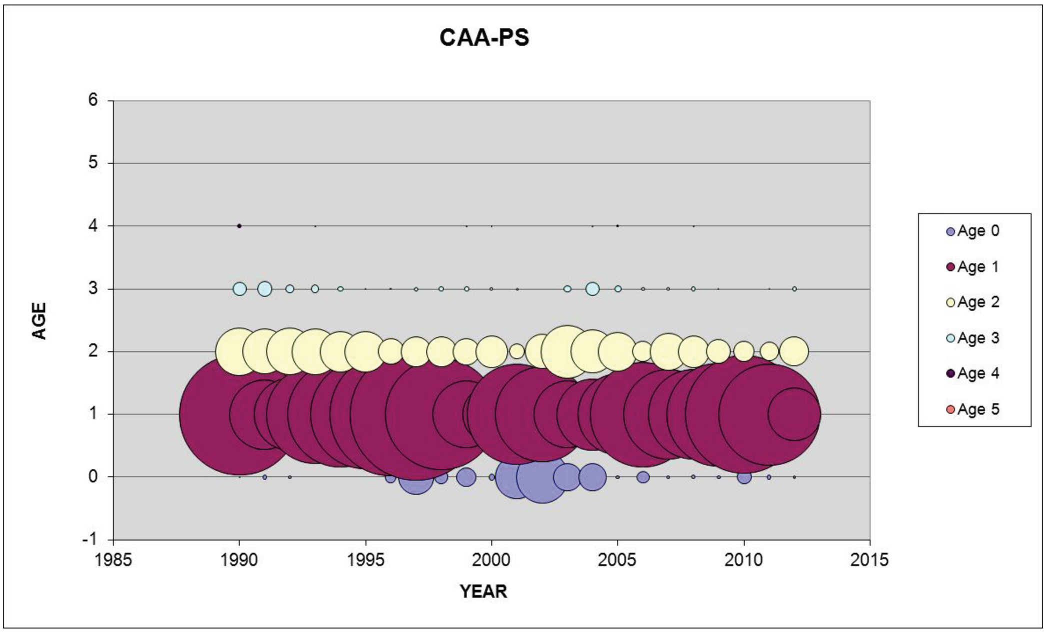

Figure 9.3.14. Catch at age of jack mackerel caught by the purse seiners in the Azores (1990-2012)

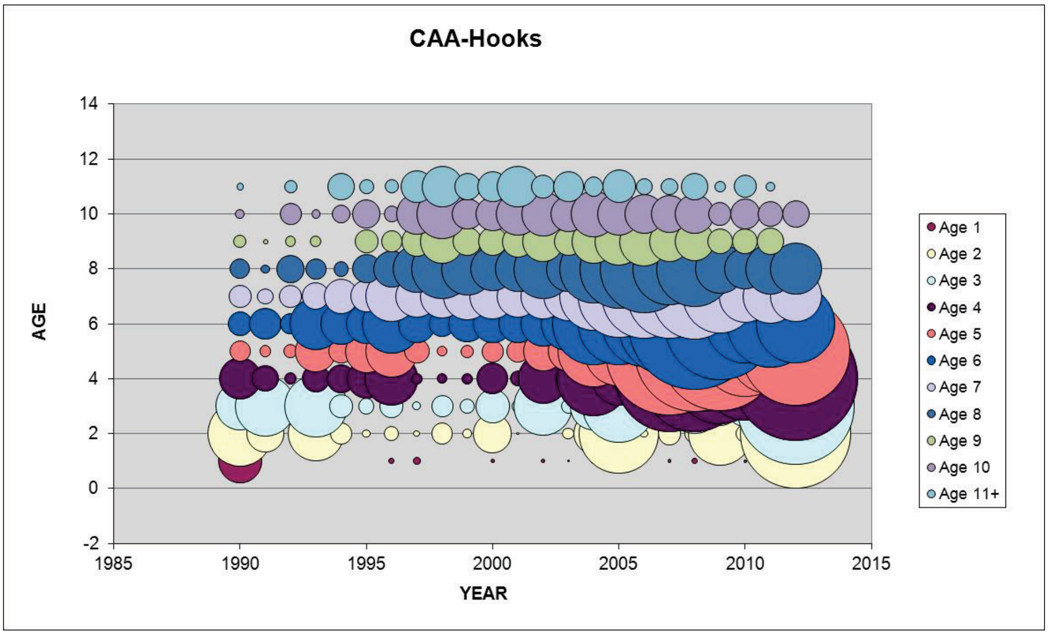

Figure 9.3.15. Catch at age of jack mackerel caught by longlines and handlines in the Azores (1990-2012)

Biological data

The jack mackerel (*Trachurus picturatus*) is one of the species included in the data collection in Azores and consequently its landings are subject to regular sampling for biological data. The biological data available includes samples from 1998 to 2011, for a total of 3434 fish.

9.3.7 Length-weight relationship

A total of 3372 specimens of jack mackerel were sampled for weight and length, and the length-weight relationships were calculate separately for males and females and for both sexes together. The parameters of the fork length to total weight relationships are given in Figure 9.4.1

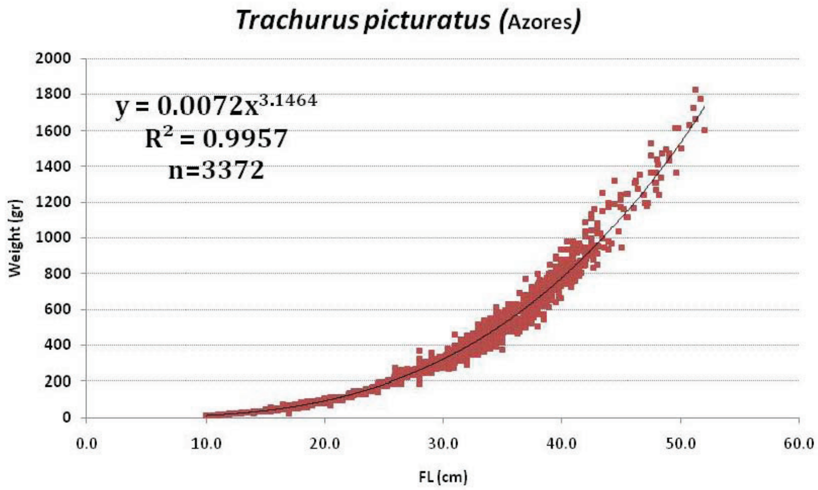

Figure 9.4.1 - Length-weight relationship for the jack mackerel (*T. picturatus*) from the Azores.

9.3.8 Maturity at length

The logistic curve fitted to the proportion of sexually mature jack mackerel estimated the mean length at sexual maturity at 28.5 cm of fork length, as showed in figure 9.4.2

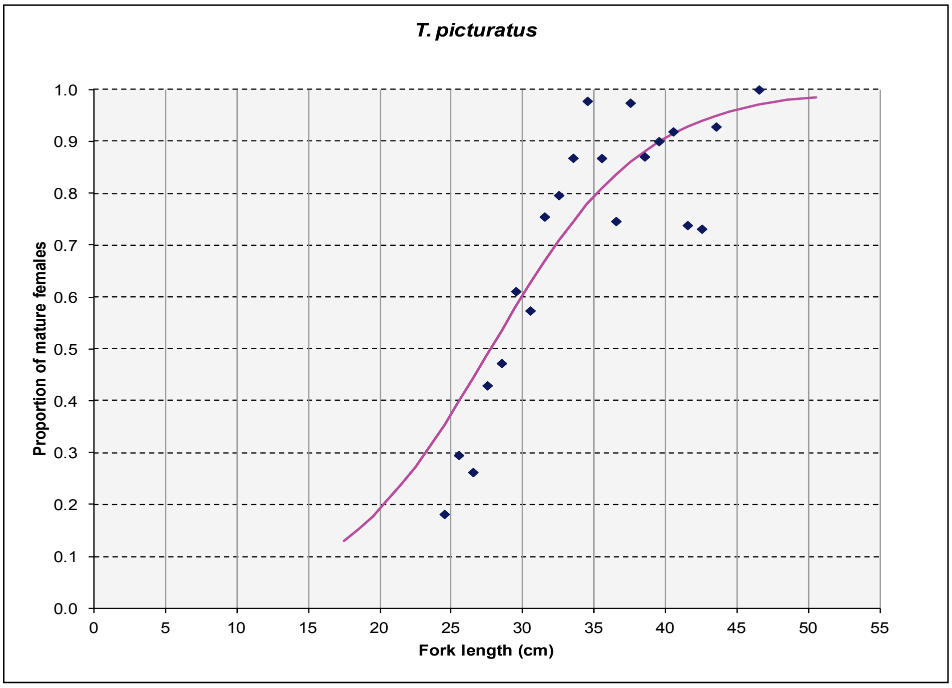

Figure 9.4.2 - Size at sexual maturity (FL50) for the jack mackerel from the Azores.

9.3.9 Age and growth

For the determination of age and growth, otoliths collected from 405 specimens where used. The smallest estimated age was 0+ and the highest 18+ (sexes pooled). Age groups 6, 7 and 8 were the dominant in the whole sample, accounting for approximately 31%. Plots of the fitted von Bertalanffy growth function are shown in Figure 9.4.3 and the estimated parameters are: L_∞=62.65 cm; *k*=0.08 year^{-1} e t_0=-2.82 year.

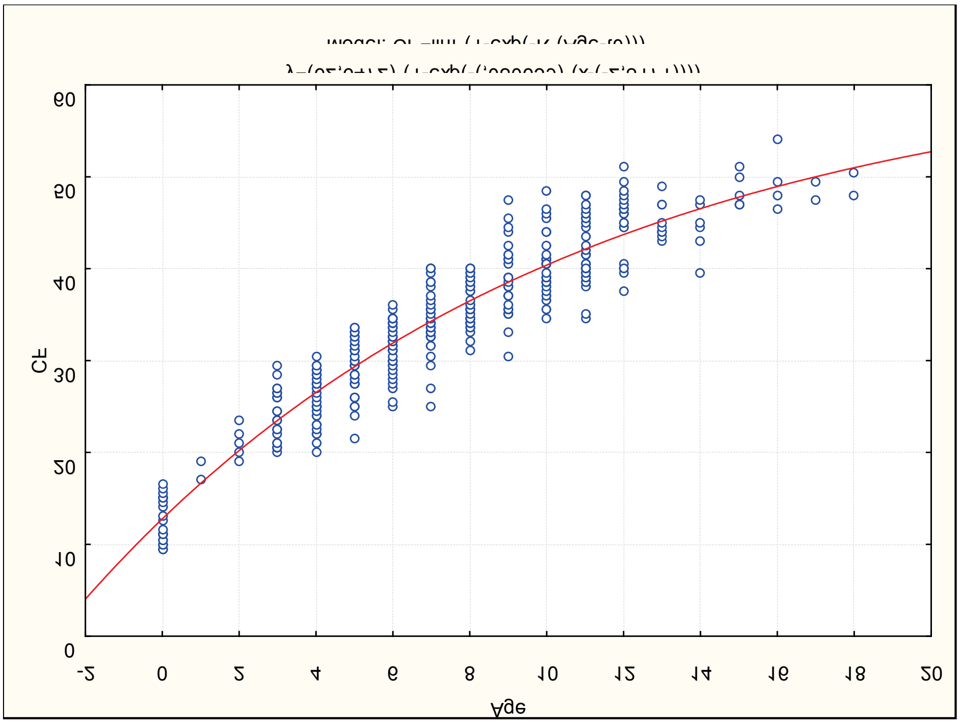

Figure 9.4.3. von Bertalanffy growth curve for *T. picturatus* from the Azores.

9.4 Assessment of the state of the stock

The jack mackerel stock from Azores is assessed for the first time. Some of the analyses were conducted during the WG meeting, with limited time. For this reason results are presented in a unique section, Data analysis.

9.4.1 Data analysis

The available information for this stock was resumed and presented to the working group on a structure for a formal stock assessment procedure. This includes: time series of landings and standardized cpue, catch at size and catch at age for the three components of the fleet. So, this stock should be classified in category 2. However, no analytical assessment using age structure models was performed because of the structure of the available data. Catch-at-age includes the age structure of juveniles and an incomplete structure of the adults. The lengths of preadults (20-30cm LF), are almost not presented on the fishery. There is no survey data available for any component of the stock. Production models were explored.

9.4.2 Trend analysis of time series

Total catches followed the artisanal seiner's decrease trend on the catches with a reduction of about 50% from the early eighties to 2002 and maintained stable thereafter around 1860 t (Fig. 9.3.3). These decrease trend observed on the artisanal purse seiner are related with voluntary management measures implemented by the industry due to market reasons.

Length compositions reflect the two different components of the exploitation: juveniles from surface fisheries and adults from benthopelagic fisheries (Fig. 9.3.12). Both time series present a stable structure with a mode around 14cm on the juveniles and 35cm on the adults suggesting equilibrium size distribution. Mean weight in the catch are stable along time (Fig. 9.3.13). Decrease observed on the hook and line mean weight is due to the discard effects (only small individuals are landed).

Standardized cpue for the main fishery (artisanal seiners) shows a decrease trend until 1987 followed by two high peaks in 1988 and 1989 and a stable trend onward. The index of abundance shows a decrease after 2011, more pronounced in 2012. This recent drop in the cpue for the purse seiners is associated to the failure of recruits at age 1 in 2012. . Hook and line cpue presents an increase trend with high variability along time. The cpue from the bait boat tuna vessels present high values since 2009, suggesting an abundance increase on individual's age 1-2. However, the last two indices present high variability. Although the tuna baitboats do not show a sharp decrease in cpue as the purse seine fleet for 2012, this could be explained since the baitboats also catch bait offshore when jack mackerel is not available in the coast

9.4.3 Production models

Standardized cpue from the different fisheries are available. Exploratory runs using production models (ASPIC 5.0) were made (Table 9.5.1). Data from the mixed demersal hook and line fishery were not used on the analysed because it comes from a by-catch fishery where most of the fish are discarded. So, data from the surface fisheries were explored. The model could not to estimate the three parameters at the same time, probably due to the lack of contrast on the data. Analyse with the two surface indices shows a slight negative correlations and more research is needed to review these indices and access how appropriate they are. Influential points of 1988 and 1989 were removed from purse seine cpue time series because the model was not able to interpret this suddenly high variability on the abundance. Sensitivity analysis was made for different input parameters (see a resume on Table 9.5.1). A final trial was attempted using only the purse seine abundance index as a base case (Run4).

The model converged and shows a reasonable fitting of the cpue series (figure 9.5.1). Results show that the stock is currently inside the safe biological limits (figure 9.5.2), with 79% of probability of getting a biomass level above Bmsy (B/Bmsy>1) and a Fishing mortality lower than Fmsy (F/Fmsy<1) (Table 9.5.1 and Fig 9.5.3).

Table 9.5.1. Exploratory runs using production models (ASPIC 5.0) made for jack mackerel

Model, parameter	Base case for assessment		Sensitivity without 1988 and 1989 years	Sensitivity without Bait boats	Sensitivity without Bait boats and 1988, 1989 years	Sensitivity without Bait boats	Sensitivity without 1988 and 1989 years	Sensitivity without Bait boats	Sensitivity without 1988 and 1989 years	Sensitivity Run 04 for B1/K=1	Sensitivity Using Bait boat index only
Run number	Run04	Run01	Run02	Run03	Run04	Run05	Run06	Run07	Run08	Run09	Run10
Model	Fox	Fox	Fox	Fox	Fox	Logistic	Logistic	Logistic	Logistic	Fox	Fox
Index	PS	PS, BB	PS, BB	PS	PS	PS, BB	PS, BB	PS	PS	PS	BB
Year of data	1978-2011	1978-2011	1978-2011	1978-2011	1978-2011	1978-2012	1978-2013	1978-2011	1978-2011	1978-2012	1978-2013
Weighting of fishery		Equal	Equal			Equal	Equal	Equal			
Objecyive function	LAV	LAV	LAV	LAV	LAV	LAV	LAV	LAV	LAV	LAV	LAV
Removed points	1988, 1989		1988, 1989		1988, 1989		1988, 1989		1988, 1989	1988, 1990	1988, 1990
MSY (t)	1,839	1,929	1,981	1,769	1,839	1,987	1,994	1,871	1,854	1,980	3,036
K (t)	83,280	69,280	73,400	93,450	83,280	63,670	68,340	70,860	77,300	73,930	86,850
B_{MSY} (t)	30,640	25,490	27,300	34,380	30,640	31,830	34,170	35,430	38,650	27,200	31,950
F_{MSY}	0.060	0.0756	0.0733	0.051	0.060	0.062	0.058	0.052	0.048	0.073	0.095
$B_{current}/B_{MSY}$	1.139	1.1	1.192	1.560	1.139	0.830	0.905	0.790	0.852	1.456	1.907
$F_{current}/F_{MSY}$	0.879	0.868	0.781	0.899	0.879	1.110	1.022	1.240	1.160	0.638	0.3188
phi	0.368	0.3679	0.3679	0.368	0.368	0.500	0.500	0.500	0.500	0.368	0.368
Equilibrium yield (t)	1,822	1,919	1,946	1,748	1,822	1,930	1,976	1,790	1,813	1,800	2,052
Convergence	Successful	Successful	Successful	Successful	Successful	Successful	Successful	Successful	Successful	Successful	Successful
Bootstrap analysis	Successful										Successful

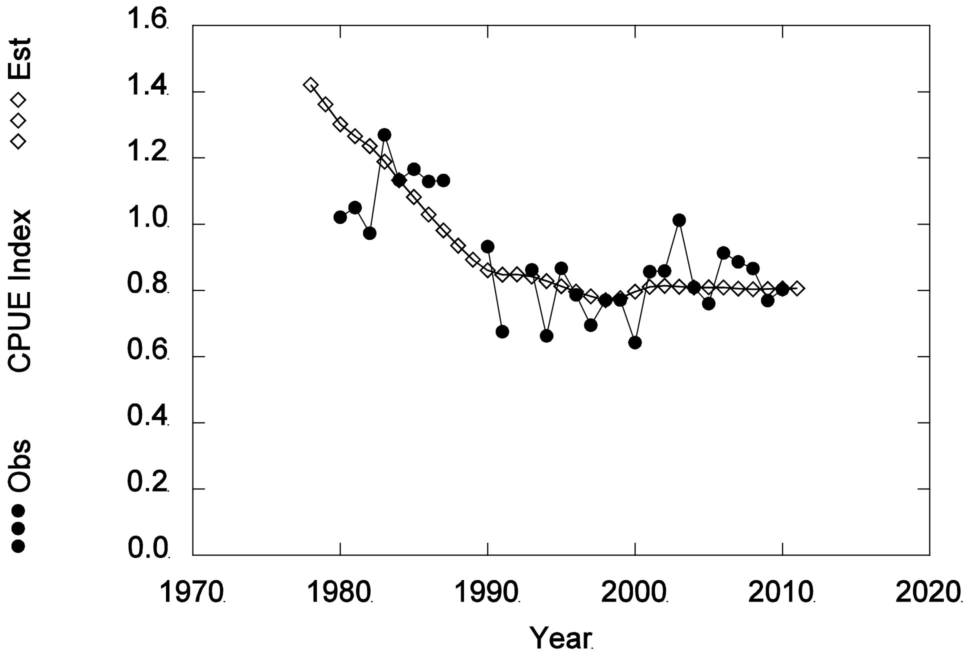

Figure 9.5.1. Trends of observed and estimated cpue in the base case production model for the Azores jack mackerel.

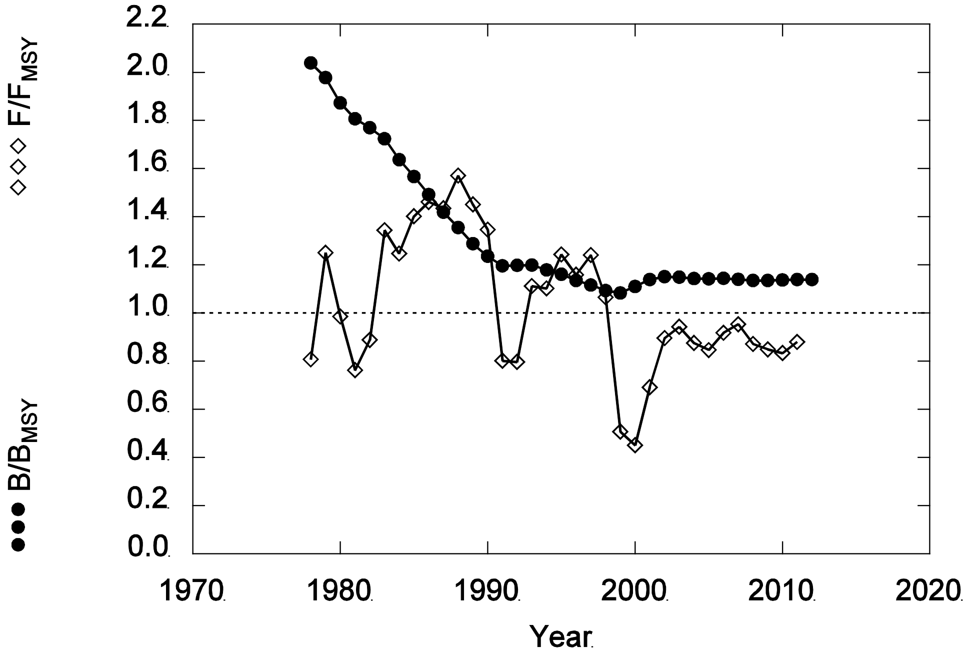

Figure 9.5.2. Relative biomass (B/Bmsy) and relative fishing mortality (F/Fmsy) trajectories estimated by the base case production model for the Azores jack mackerel.

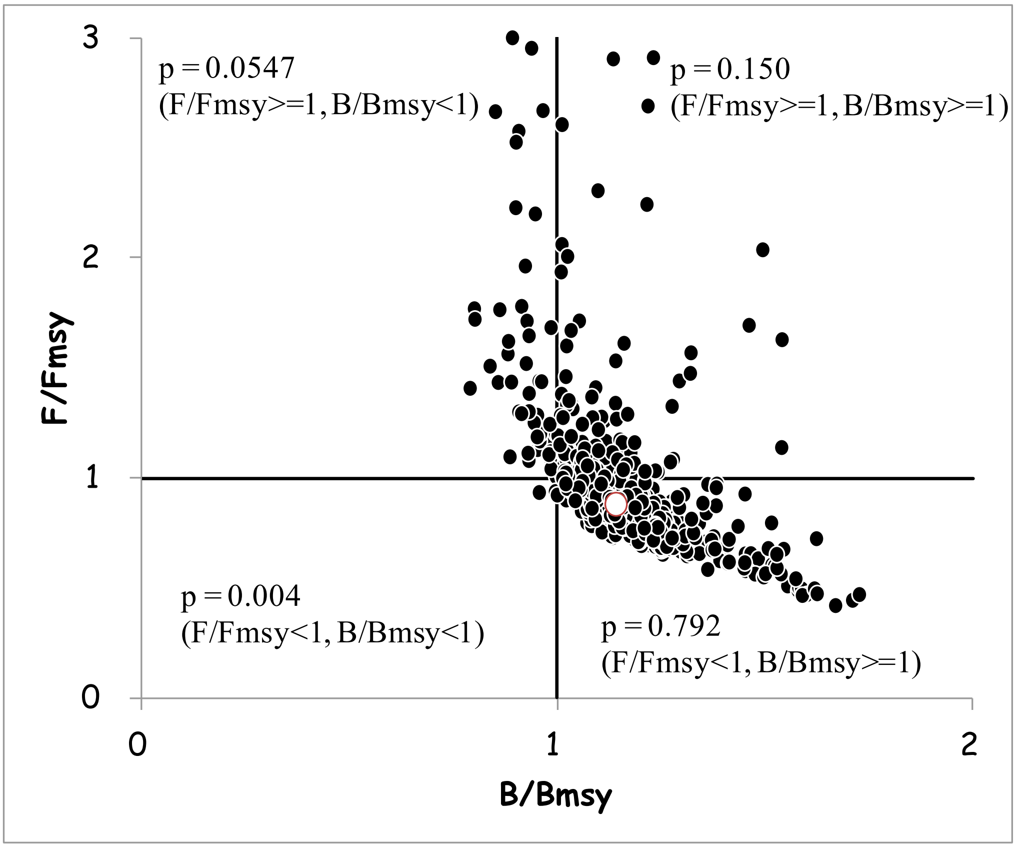

Figure 9.5.3. Results of bootstrap examination from the base case production model for the Azores jack mackerel. Biomass ratios and fishing mortality ratios for most recent year of assessment (2011). The model estimates a probability of 0.79 that the stock is not overfished and it is not undergoing overfishing. Points represent 1000 bootstraps, large circle correspond to median.

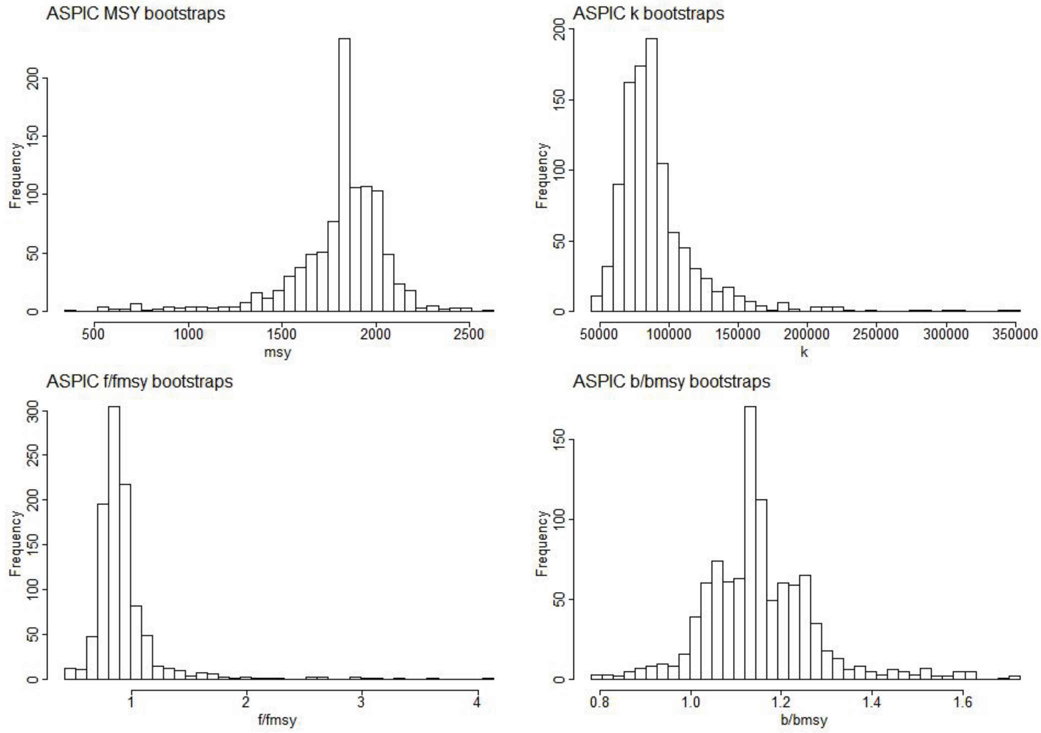

Figure 9.5.4. Histogram distribution of bootstrap results from the base case production model for the Azores jack mackerel.

9.4.4 Yield per recruit analysis

A YPR analysis was performed. The input parameters Loo=62,6 , K=0,08 To=-2,82, M=0,2, cm(L_{mat}/L_{inf})=0,44 and c(Lc/L_{inf})=0,22) were adopted.

An attempted was made to estimate total mortality (Z) from the catch curve applied to the fishery length frequency or age data. Length composition shows a clear differentiated mortality for juveniles (surface fisheries) and adults (hook and line fisheries). The estimated values were probably overestimated for the juveniles (Z= 2-4 year^{-1}) and adults (Z=0.4-0.7 year^{-1}), because of the gear selection effects. YPR results suggest that $F_{0.1}$ seems to be the appropriate target reference point for the species corresponding to a long term fishing mortality of F=0.11 year^{-1}.

	Fmax	F0.1	$F_{20\%BPR}$	$F_{30\%BPR}$	$F_{35\%BPR}$	$F_{40\%BPR}$
F	0,18	0,11	0,22	0,15	0,13	0,11
%BPR	0,25	0,40	0,20	0,30	0,35	0,40
%SPR	0,17	0,32	0,12	0,22	0,27	0,33

9.5 Management considerations

The catches of jack mackerel in recent years average 1850 tonnes. The jack mackerel is mostly landed by the artisanal fleet, using purse seines and their catches have been maintained at a relatively stable level since 1990, by an auto regulation adopted by the fisherman association, due to market restrictions. This stability of the catches is mostly observed in S. Miguel Island, where around 70% of the annual catches occur. Continuous reductions in the demands from the consumers lead to the catch limits auto adopted by the fleet, which explains the reduction observed in the catches along the recent years

Standardized cpue for the small purse seiners fishery shows that the relative abundance of jack mackerel as a stable trend in during the exploitation period. Standardized cpue for tuna bait boat fishery shows an increasing trend in the relative abundance of jack mackerel since 2006. In the case of the longliners, the decrease observed in the last 2 years is explained by the fact that the cpue is based on landings and the fleet has reduced its landings of 70% in recent years.

The production model estimates a probability of 0.79 that the stock is not overfished and it is not undergoing overfishing.

Considering the status of the stock and that the catches have been maintained at a relatively stable level since 1990, by an auto regulation adopted by the fisherman association, there is no reason to make any changes to the current management measures.

10 General Recommendations

WGANSA 2013 General Recommendations	**to**
The WGHANSA recommends that anchovy catches in the western part of Division IXa are sampled whenever an outburst of the population in the area is detected.	PGCCDBS, RCM's
The Benchmark for anchovy in IXa is recommended to be delayed to 2015, basically due to limited man power and to allow for the new DEPM 2014 survey to be examined by WGACEGGs in Nov2014 and to input the Benchmark.	ICES secretariat

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Annex A.1 List of Participants

Working Group on Anchovy, Sardine and Horse Mackerel

(WGHANSA)

21 - 26 June 2013

Bilbao, Spain

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Annex A.2 List of Working Documents and Presentations

Duhamel, E., Doray, M., Huret, M., Doremus, G., Pengrech, A. WD 2013. Direct assessment of small pelagic fish by the PELGAS13 acoustic survey. PELGAS13 Survey Report. 30p.

Abstract: An acoustic survey was carried out in the Bay of Biscay from April 24st to June 3th on board the French research vessel Thalassa. The objective of PELGAS13 survey was to study the abundance and distribution of pelagic fish in the Bay of Biscay. The target species were mainly anchovy and sardine and were considered in a multi-specific context. To assess an optimum horizontal and vertical description of the area, two types of actions were combined: i) Continuous acquisition by storing acoustic data from five different frequencies and counting the number of fish eggs using CUFES system, and discrete sampling at stations**. C**ommercial vessels were accompanying Thalassa for most of the time, such as to double the number of identifications hauls and increase the reliability of identification of echoes. This WD reports acoustic assessments and length distributions of main species, age distribution for anchovy and sardine and some environmental data. Anchovy was present this year as an abundance index around the average on the serie, 93 854 tonnes, including one fourth of this abundance in the surface layer The biomass estimate of sardine observed during PELGAS13 is 407 740 tons, which is a bit upper than the average level of the PELGAS series, and constituting a new increase of the biomass.

L. Ibaibarriaga and A. Uriarte. WD 2013: Some pending issues from WKPELA on the assessment of Bay of Biscay anchovy

Abstract: In the ICES Benchmark Workshop on Pelagic Stocks the assessment method (including projections) and appropriate reference points for anchovy in the Bay of Biscay were considered. However some issues were not finalised and remained to be further studied. In this document we try to address some of these items. In particular, we (a) test the sensitivity of the results to different prior distribution of the catchability of the JUVENA surveys, (b) compare the linear and the potential model and (c) do a retrospective analysis of the assessments conducted in December, so that the prediction capacity of the different model options can also be tested.

Vítor Marques, Alexandra Silva, Maria Manuel Angélico and Eduardo Soares, WD 2013: Sardine acoustic survey carried out in April-May 2013 off the Portuguese Continental Waters and Gulf of Cadiz, onboard RV "Noruega"

Abstract The main results of the Portuguese acoustic survey directed to sardine and anchovy estimates in ICES sub area IX shows a reduction in sardine and anchovy biomass. The sardine abundance was the lowest of the time series, following the tendency of the last years. In the Occidental north zone (OCN), the estimated biomass was very low (9 thousand tonnes). Age 1 was predominant in the survey area although the absolute number was very low indicating a low 2012 recruitment.

The anchovy abundance suffered a strong reduction in the west coast area. On the contrary in the South coast, anchovy biomass shows a recovering, in relation to the last year. Age 1 anchovy was predominant in the north while age 2 was predominant in the south.

The 2013 spring acoustics survey took place one month later than planned and lasted longer than usual due to bad weather during the north area coverage. Although the acoustic coverage was interrupted several times, the survey itself was done in good conditions and we considered the estimate is comparable with previous surveys.

The CUFES egg distribution matched the sardine acoustic energy mapping. The higher egg abundances also coincided with the major schools found over the Promontório da Estremadura, south of Peniche.

Petitgas, P., Huret, M., Doray, M. Coherence between CUFES and Acoustic PELGAS survey indices (Bay of Biscay anchovy).WD for the 2013 WGHANSA. 4p

Abstract : In the Bay of Biscay, the survey PELGAS of Ifremer delivers an abundance index of the anchovy population based on the acoustic methodology. The egg pump CUFES is also operated along the acoustic survey transects, which provides the means to estimate a total daily egg production. The CUFES Ptot series could be used as a new additional survey index for input in the ICES assessment model and higher/ lower weights given to years showing coherence/ discrepancy between Ptot and B. When survey estimates disagree in particular years, one may consider the survey indices as less reliable than for the years showing agreement. Therefore, a weighting depending on the coherence between survey estimates could be worth investigating as input to the ICES assessment model.

Petitgas, P., Duhamel, E., M., Doray, M. Coherence between Egg (BIOMAN) and Acoustic (PELGAS) .

Abstract : In the Bay of Biscay anchovy abundance is estimated by acoustics (PELGAS series of Ifremer) and DEPM (BIOMAN series of Azti). The egg survey provides an estimate of total daily egg production and the acoustic survey an estimate of spawning biomass. To estimate DF, we take advantage of the fact that we have an egg survey providing Ptot estimates and an acoustic survey providing Biomass (B) estimates. We may simply access to DF by the ratio Ptot/B. Because the two indices Ptot and B are linked through DF, the coherence between the egg and the acoustic surveys BIOMAN and PELGAS can be investigated.

When survey estimates disagree in particular years, one may consider the survey indices as less reliable than for the years showing agreement. Therefore, a weighting depending on the coherence between survey estimates could be worth investigating as input to the ICES assessment model.

Nuno Prista and Ana Cláudia Fernandes, WD 2013: Update on the discards of WGHANSA species by the Portuguese bottom otter trawl fisheries in ICES Division XIa (2012).

Abstract: We compile the information available on the discards of WGHANSA stocks produced by Portuguese vessels operating with bottom otter trawl in Portuguese ICES Division IXa. The data was collected by the Portuguese on-board sampling programme (EU DCR/NP) between 2004 and 2012. Fleet level estimates of discards volume and length composition of horse mackerel and sardine are provided for some years * species * fisheries combinations.

Ramos, F., Iglesias, M., Miquel, J., Oñate, D., Tornero, J., Ventero, A., Díaz, N., WD 2013. Acoustic assessment and distribution of the main pelagic fish species in the ICES Subdivision IXa South during the *ECOCÁDIZ-RECLUTAS 1112* Spanish survey (November 2012).

Abstract: ECOCÁDIZ-RECLUTAS 1112 survey is the second survey by the IEO of acoustically assessing the abundance of anchovy and sardine juveniles in their main recruitment areas off the Gulf of Cádiz. The survey was conducted between 10th and 27th November 2012 onboard the Spanish R/V Emma Bardán and its sampled area was restricted only to the Spanish waters of the Gulf of Cádiz between 10 and 200 m depth.

Acoustic estimates from the surveyed area were as follows:

Estimate	Anchovy	Sardine	Chub mack.	Mackerel	Horse-mack.	Medit. h-mack.	Blue jack-mack.	Bogue	Total spp.
Biomass (t)	13680	22119	11155	1136	15873	3375	976	346	68660
Abundance (millions)	2649	603	157	11	1049	148	37	7	4661

The abundance and biomass of age 0 anchovies in the surveyed area were estimated at 13 354 t and 2 619 million fish, respectively, i.e. 97% and 99% of the total estimated anchovy biomass and abundance. Sardine estimates were not age-structured but the abundance and biomass of juveniles smaller than 17 cm were estimated at 9 675 t and 377 millions, 44% and 62% of the total estimated species' biomass and abundance. The resulting yields and location of positive fishing stations with anchovy from a groundfish survey carried out shortly before the present survey are also shown and provide a complementary picture of the anchovy juvenile distribution during the survey season.

Isabel Riveiro, Pablo Carrera, Magdalena Iglesias, Joan Miquel and Dolores Oñate, WD 2013: Preliminary results of the Pelacus0313 survey: estimates of sardine abundance and biomass in Galicia and Cantabrian waters

Abstract The PELACUS 0313 survey was undertook this year on board R/V Miguel Oliver, an oceanographic stern trawler ship similar to Thalassa. The survey was characterised by a very bad weather conditions during the first two weeks which did not allow working properly. Moreover, the weather conditions during the rest of survey were almost similar. As a consequence, most of the coastal pelagic fish community remained very close to the coast, thus not accessible to the pelagic gear samplers. (33% of the total acoustic energy –NASC- was unable to be properly allocated into fish species). Outside the coastal area (>90 m depth) sardine distribution was scarce, and occurred in small schools (probably as a consequence of the bad weather condition). It was only found in a small area in VIIIc-West and in the eastern part of the VIIIc-East. The total biomass estimated in this area was 2.530 tonnes corresponding to 38,4 million fish. Together with this assessment, made on account the fish proportion found at the ground truth fishing station, a direct assignation was achieved by echogram scrutinization. Although the experience, only few schools could be properly allocated to sardine, all of them located inside the Rias Baixas, giving an estimation of 813 tonnes (16 million fish). Overall, total biomass estimation is 3.343 tonnes, corresponding to 54 million fish.

On the contrary, the number of sardine eggs found at the CUFES stations showed an increase compared to those found in 2012 (from 1665 to 5936). Nevertheless, the dis-

tribution area was rather similar, with a significant gap between the southern area (IXaN) and the inner part of the Bay of Biscay (VIIIc-East-east). Given the amount of unallocated schools in shallower waters, the acoustic sardine assessment is considered unreliable since only the inner part of the distribution (waters deeper than 90 m) was properly surveyed. The egg distribution, similar to that found the last year could indicate that the stock estimation would be similar. On the other hand, the significant increase in egg

number would be either related with the shift in the survey time (two weeks earlier than the previous year), thus arriving at the peak spawning, or with an increase in the sardine abundance.

M. Santos, L. Ibaibarriaga, G. Boyra and A. Uriarte, WD 2013: Preliminary index of biomass of Bay of Biscay anchovy (Engraulis encrasicolus, L.) in 2013 applying the DEPM and sardine total egg abundance.

Abstract. The research survey BIOMAN 2013 for the application of the Daily Egg Production Method (DEPM) in the Bay of Biscay anchovy was conducted in May 2013 from the 9th to the 28th covering the whole spawning area of the species. Two vessels were used: the R/V Ramón Margalef to collect the plankton samples and the pelagic trawler Emma Bardán to collect the adult samples. The total area covered was 77,838Km2 and the spawning area was 35,448Km2. During the survey 551 vertical plankton samples were obtained, 1,222 CUFES samples and 30 pelagic trawls were performed, from which 22 contained anchovy and 21 of them were selected for the analysis, the other one was rejected due to the small amount of individuals in the sample. No anchovy eggs were found in the Cantabrian Coast. The spawning area started at 43º45’N in the French platform and the northern limit was found at 46º15’N. The eggs in the French platform where encountered in the historical common places: Between Adour and Arcachon and in the area of influence of Le Gironde. The conditions of the survey were in general wintry, with a mean SST of 14.3ºC. The sampling was stopped for 12 hours due to bad weather at R 51. The cufes was broken and the sampling with cufes was stopped for 5 hours. Another cufes was then used at 4m. Moreover, the sampling was stopped during 40h at R 44 for refuel gas oleo. Total egg production (Ptot) was calculated as the product of the spawning area and the daily egg production rate (P0), which was obtained from the exponential decay mortality model fitted as a Generalized Linear Model (GLM) to the egg daily cohorts. The adult parameters, Sex Ratio, preliminary Batch Fecundity and Weight of mature females, were estimated based on the adult samples obtained during the survey and the Spawning frequency estimate was obtained as the mean of the historical series old and new. The index of biomass estimate taken the old series of S resulted in 65,909 t with a coefficient of variation of 16% and taken the new series of S resulted in 40,797t with a coefficient of variation of 16%. Until the implementation of the new series of S we adopted the index of biomass of 65,909t. Total abundance of sardine was 5.5 E12 eggs, at levels of last year.

Alexandra Silva, Andres Uriarte, Isabel Riveiro, Begoña Santos, Manuela Azevedo, Alberto Murta, Pablo Carrera, Leire Ibaibarriaga, Dankert Skagen. WD 2013: Reference points for the Iberian sardine stock (ICES areas VIIIc and IXa).

Abstract: Three Yield-Per-Recruit/stock-recruitment approaches (deterministic, stochastic with plotMSY and stochastic with HCS) were used to explore reference points for the management of the Iberian sardine. The sensitivity of reference points was evaluated in relation to alternative scenarios of productivity, growth and selectivity. Growth and selectivity scenarios had a small impact on stock projections whereas

productivity scenarios were very influential. The three approaches gave coherent results, but the approach using HCS, assuming uncertainty in stock biology and recruitment dynamics, was preferred to derive reference points for sardine. In this approach, the risks of the stock falling below some low biomass level can also be taken into account. This possibility was considered to be useful in the case of the sardine for which exploitation at maximum YPR or F0.1 resulted in values above historical exploitation and higher than Floss, therefore unsuitable as precautionary management targets.

Bloss (306 thousand t) is proposed as a proxy for Blim but given no indication that recruitment is impaired below this biomass level, the group considers that the level of risk of falling below this candidate for Blim acceptable in the evaluation of a management plan should be higher than the standard ICES value (5%).The stock productivity has declined over time; therefore a scenario of low productivity was assumed (recruitment in the period 1993-2010). Under this productivity scenario, the Fmsy value for the sardine stock is 0.34, a value associated with a high probability (45%) of the biomass falling below the proposed Blim and therefore, incompatible with precautionary considerations. The WG proposes an F= 0.27, corresponding to a Prob(B<Blim)<15% under equilibrium, as the best available candidate for an F management target (proxy for Fmsy) assuming the low productivity scenario (since 1993) will continue in the future. This F provides high yield conditional to a low probability that the biomass falls below Blim=Bloss in equilibrium, thus incorporating precautionary considerations.

Annex A.3 Appending Relevant Working Documents

WDs in pdf on following pages.

Direct assessment of small pelagic fish by the PELGAS13 acoustic survey

Erwan Duhamel[1], Mathieu Doray[2], Martin Huret[1],
Ghislain Doremus[4] and Alexis Pengrech[3]

Special thanks to, Jacques Massé, , Florence Sanchez[5], Pierre Petitgas[2],Lionel Pawlowsk[1]

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1. Material and method

1.1. PELGAS survey on board Thalassa

Acoustic surveys are carried out every year in the Bay of Biscay in spring onboard the French research vessel Thalassa. The objective of PELGAS surveys is to study the abundance and distribution of pelagic fish in the Bay of Biscay. The main target species are anchovy and sardine but they are considered in a multi-specific context and within an ecosystemic approach as they are located in the centre of pelagic ecosystem.

These surveys are connected with IFREMER programs on data collection for monitoring and management of fisheries and ecosystemic approach for fisheries. This task is formally included in the first priorities defined by the Commission regulation EU N° 199/2008 of 06 November 2008 establishing the minimum and extended Community programmes for the collection of data in the fisheries sector and laying down detailed rules for the application of Council Regulation (EC) No 1543/2000. These surveys must be considered in the frame of the Ifremer fisheries ecology action "resources variability" which is the French contribution to the international Globec programme. It is planned with Spain and Portugal in order to have most of the potential area covered from Gibraltar to Brest with the same protocol regarding sampling strategy. Data are available for the ICES working groups WGHANSA, WGWIDE and WGACEGG.

In the spirit of the ecosystemic approach, the pelagic ecosystem is characterised at each trophic level. To achieve this and to assess an optimum horizontal and vertical description of the area, two types of actions are combined :

1) Continuous acquisition of acoustic data from six different frequencies and pumping sea-water under the surface in order to evaluate the number of fish eggs using a CUFES system (Continuous Under-water Fish Eggs Sampler)

2) discrete sampling at stations (by pelagic trawls, plankton nets, CTD). Satellite imagery (temperature and sea colour) and modeling have been also used before and during the survey to recognise the main physical and biological structures and to improve the sampling strategy. Concurrently, a visual counting and identification of cetaceans and birds (from board) carried out in order to characterise the higher level predators of the pelagic ecosystem.

The strategy this year was the identical to previous surveys (2000 to 2012). The protocol for acoustics has been described during WGACEGG in 2009 (*Doray et. Al,2009*):

- acoustic data were collected along systematic parallel transects perpendicular to the French coast (figure 1.1.1). The length of the ESDU (Elementary Sampling Distance Unit) was 1 mile and the transects were uniformly spaced by 12 nautical miles and cover the continental shelf from 20 m depth to the shelf break (or sometimes more offshore – see figure below).

- acoustic data were only collected during the day because of pelagic fishes behaviour in this area. These species are usually dispersed very close to the surface during the night and so "disappear" in the blind layer of the echo-sounders between the surface and 8 m depth.

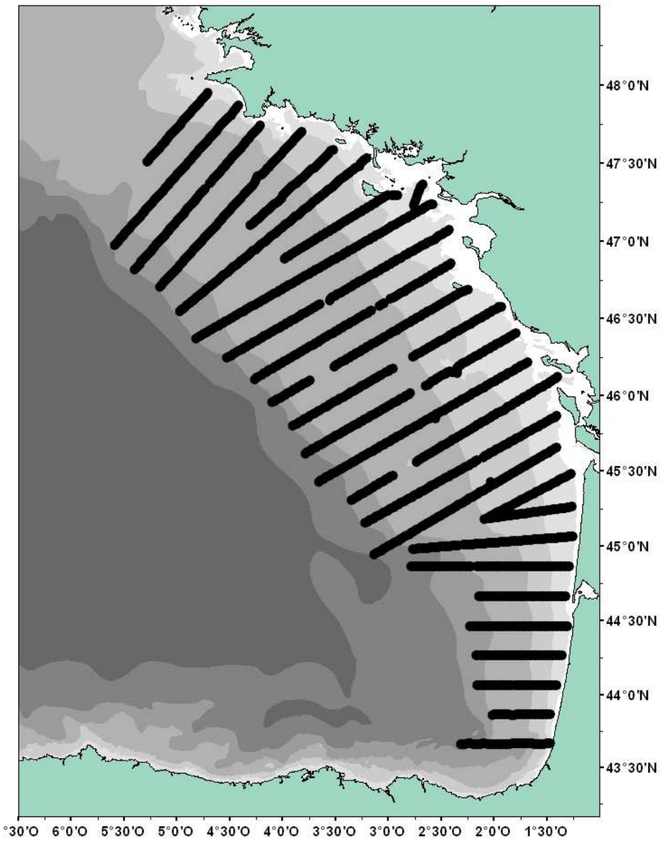


Fig. 1.1.1 - Transects prospected during PELGAS13 by Thalassa.

Three different echo-sounders were used during the survey :

In 2013, as in previous surveys (since 2009), three modes of acoustic observations were used :

- 6 split beam vertical echo-sounders (EK60), 6 frequencies, 18, 38, 70, 120, 200 and 333 kHz

- 1 horizontal echo-sounder on the starboard side for surface echo-traces
- 1 SIMRAD ME70 multi-beam echo-sounder (32 x 2°beams, from 70 to 120 kHz) used essentially for visualisation to observe the behaviour and shapes of fish schools during the whole survey. Nevertheless, only echoes stored on the vertical echo-sounder were used for abundance index calculation.

Energies and samples provided by all sounders were simultaneously visualised and stored using the MOVIES+ and MOVIES3D software and stored at the same standard HAC format.

The calibration method was the same that the one described for the previous years (see WD 2001) and was performed at anchorage in the Douarnenez bay, in the West of Brittany, in medium meteorological conditions at the end of the survey.

Acoustic data were collected by R/V Thalassa along a total amount of 6500 nautical miles from which 1770 nautical miles on one way transect were used for assessment. A total of 24 432 fishes were measured (including 6260 anchovies and 5910 sardines) and 2633 otoliths were collected for age determination (1249 of anchovy and 1384 of sardine).

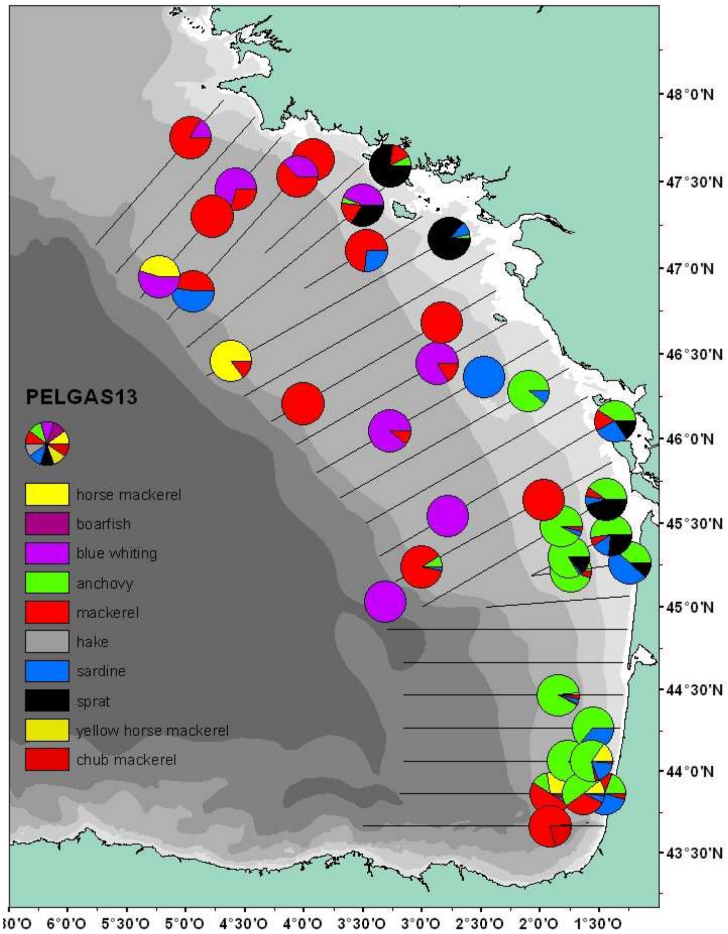


Fig. 1.1.2: Species distribution according to Thalassa identification hauls.

1.2. The consort survey

A consort survey is routinely organised since 2007 with French commercial vessels during 18 days. This approach, in the continuity of last year survey, and their trawl hauls were used for echoes identification and biological parameters at the same level than Thalassa ones.

Five commercial vessels (two pairs of pelagic trawlers during the two first weeks and a single pelagic trawler for the 4 last days) participated to PELGAS13 survey:

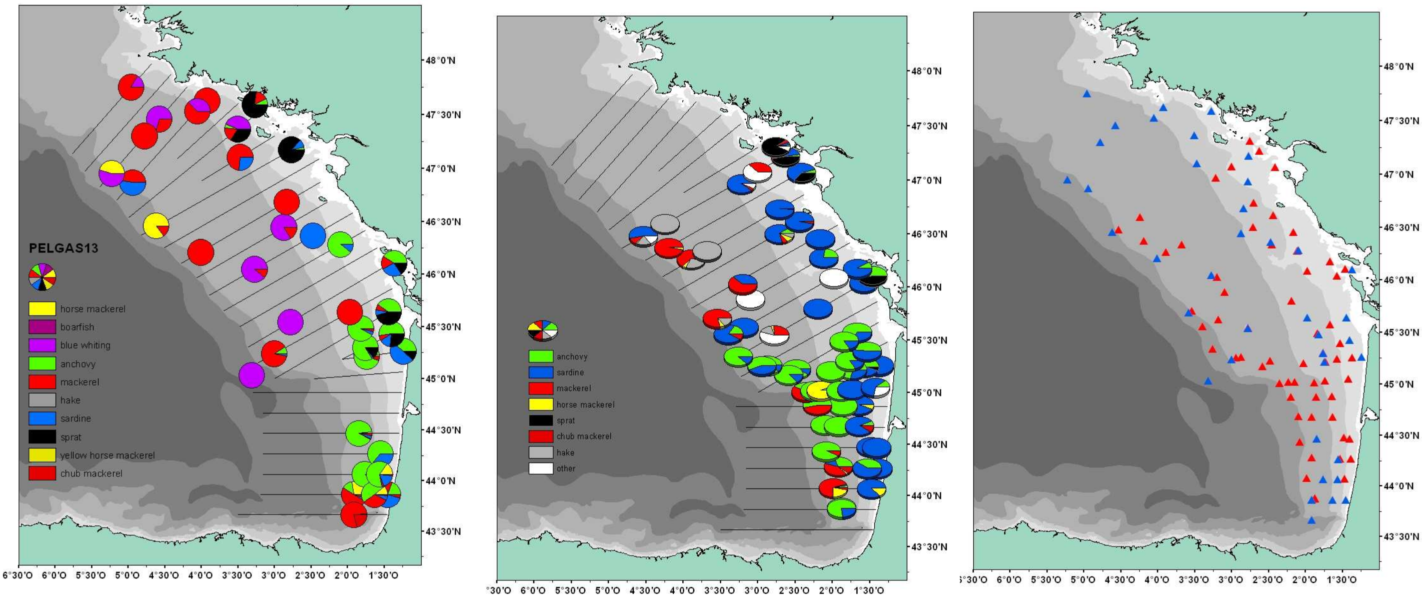
Vessel	gear	Period	Days at sea
Jérémi-Simon / Prométhée	Pelagic pair trawl	29/04 to 05/05/2013	7
Maïlys-Charlie / Pen Kiriac III	Pelagic pair trawl	06/05 to 12/05/2013	7
Bara Pemdez II	Pelagic single trawl	15/05 to 18/05/2011	4

The regular transects network agreed for several years for Thalassa is 12 miles separated parallel transects. Commercial vessels worked between standard transects and 2 NM northern. Sometimes, they carried out fishing operations on request (complementary to Thalassa, particularly for surface hauls or in very coastal areas) Their pelagic trawl was until 25 m vertical opening and the mesh of their codend was similar to Thalassa (12 mm).

A scientific observer was onboard to control every operation, and to collect biological data. The fishing operations were systematically agreed after a radio contact with Thalassa in order to confirm their usefulness. In some occasions, the use was to check the spatial extension of species already observed and identified by Thalassa (and therefore the spatial distribution), in others the objective was to enlarge the vertical distribution description by stratified catches. Globally, a great attention was given on a good distribution of samples to avoid over-sampling on some situations. Regularly a biological sample was provided by commercial vessels to Thalassa to improve otoliths collection and sexual maturity (18 samples of sardine, 15 of anchovy). A total of 10 600 fishes were measured onboard commercial vessels, including 4103 anchovies and 4067 sardines.

The catches and biological data have been directly used with the same consideration than Thalassa ones for identification and biological characterisation.

A total of 101 hauls were carried out during the assessment coverage including 39 hauls by Thalassa and 62 hauls by commercial vessels.



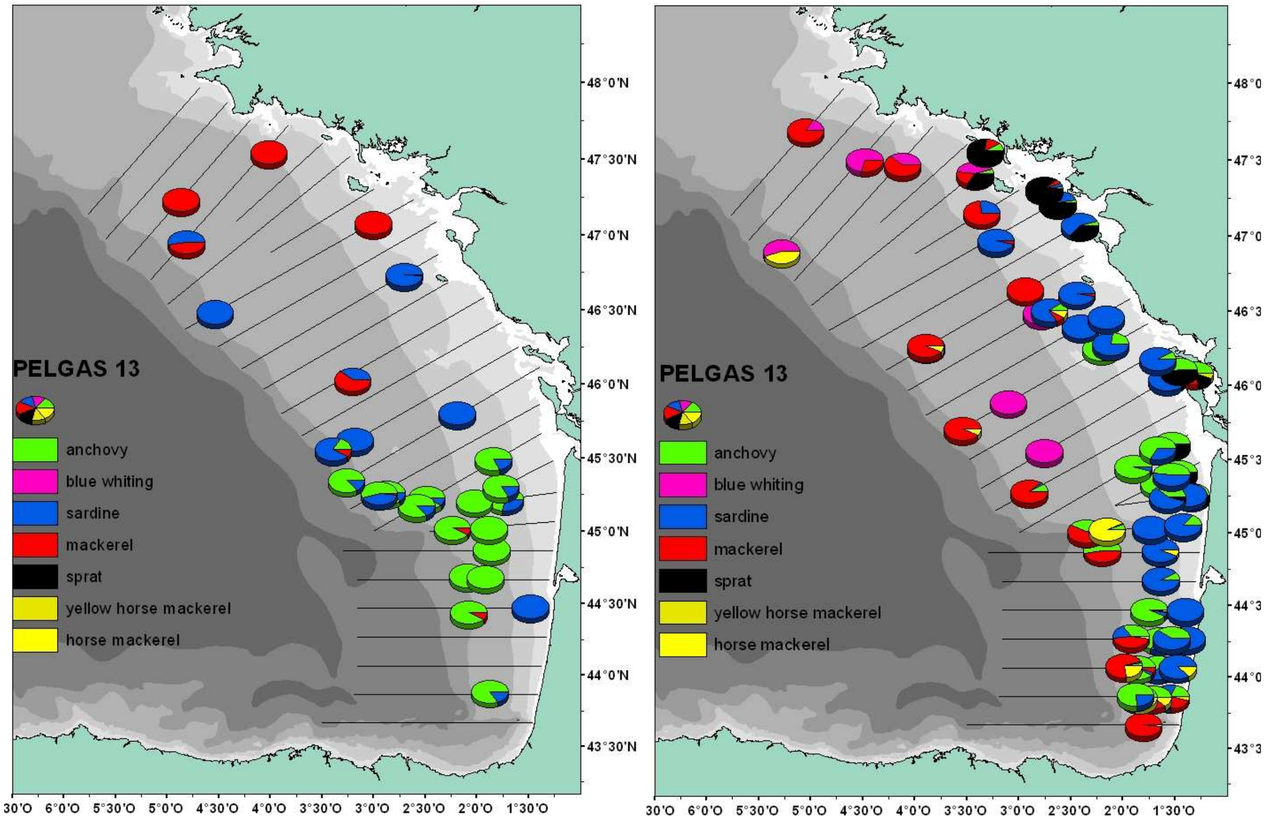
a) Thalassa (nb :39) *b) Commercial vessels (nb : 62)* *c) all fishing hauls (nb :101)*

Figure 1.2.2 : fishing operations carried out by Thalassa and commercial vessels during consort survey PELGAS13

The collaboration between Thalassa and commercial vessels was excellent. It was once more a very good opportunity to explain to fishermen our methodology and furthermore, to verify that both scientists and fishermen observe the same types of echo-traces and have similar interpretations. Some fishing operations were done in parallel by Thalassa and commercial vessel in order to check if the catches were well comparable (in proportion of species and, most of the time, in quantity as well). As last year, the fishing operations by commercial vessels were carried out only during day time (as for Thalassa) each time it was necessary and preferentially at the surface or in mid-water, since the pair trawlers are more efficient at surface than single back trawlers.

	R/V Thalassa	**Commercial vessels**	**Total**
Surface Hauls	**3**	**35**	**38**
Classic Hauls	**29**	**23**	**52**
Valid	**32**	**58**	**90**
Null	7	4	11
Total	39	62	101

Table 1.2.3. : number of fishing operations carried out by Thalassa and commercial vessels during consort survey PELGAS13



a) Hauls carried out at surface or in mid-water levels (Thalassa & commercial vessels)

b) classic Hauls carried out near the bottom and 50m upper (Thalassa + commercial vessels)

Figure 1.2.4 : Vertical localisation of fishing operations carried out by Thalassa and commercial vessels during survey PELGAS13

2. Acoustics data processing

2.1. Echo-traces classification

All the acoustic data along the transects were processed and scrutinised by the date of the meeting (figure 2.2.1). Acoustic energies (Sa) have been cleaned by sorting only fish energies (excluding bottom echoes, parasites, plankton, etc.) and classified into 4 categories of echo-traces this year :

D1 – energies attributed to mackerel, chub mackerel, horse mackerel, blue whiting, hake, whiting, corresponding to cloudy schools or layers (sometimes small dispersed points) close to the bottom or of small drops in a 10m height layer close to the bottom.

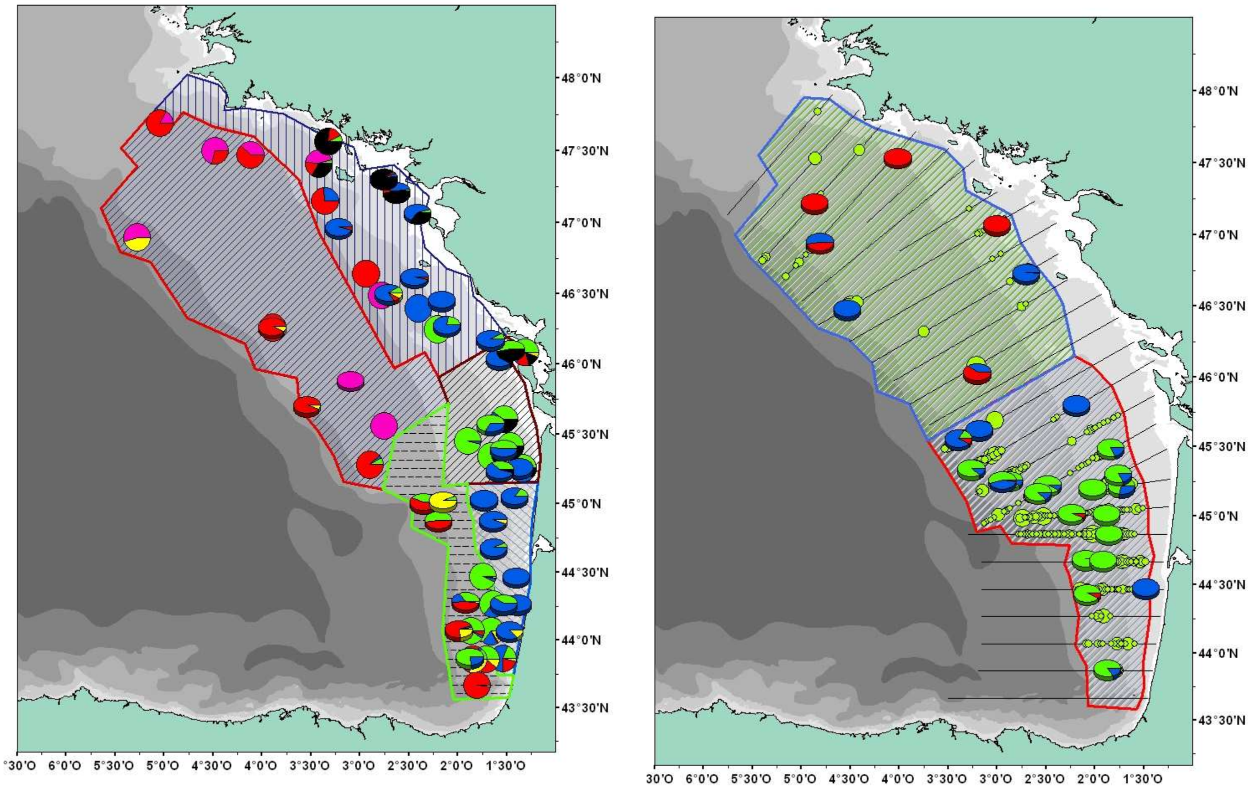
D2 –energies attributed to anchovy, sardine, and sprat corresponding to the usual echo-traces observed in this area since more than 15 years, constituted by schools well defined, mainly situated between the bottom and 50 meters above. These echoes are typical of clupeids in coastal areas and sometimes more offshore.

D4 – energies attributed to sardine, mackerel and anchovy corresponding to small and dense echoes, very close to the surface.

D8 – energies attributed exclusively to sardine (big and very dense schools).

2.2. Splitting of energies into species

As for previous years (except in 2003, see WD-2003), the global area has been split into several strata where coherent communities were observed (species associations) in order to minimise the variability due to the variable mixing of species. Figure 2.2. shows the strata considered to evaluate biomass of each species. For each strata, energies where converted into biomass by applying catch ratio, length distributions and weighted by abundance of fish in the haul surrounded area.



Coherent classic strata

Coherent surface strata

Fig. 2.2. – Coherent strata (classic and surface), in terms of echoes and species distribution, taken into consideration for multi-species biomass estimate from acoustic and catches data during PELGAS13 survey.

2.3. Biomass estimates

The fishing strategy has been followed all along the survey in order to profit of the best efficiency of each vessel and maximise the number of samples (in term of identification and biological parameters as well). Therefore, the commercial vessels carried out mostly surface hauls when Thalassa fish preferably in the bottom layer. According to previous strata, using both Thalassa and consort fishing operations, biomass estimates have been calculated for each main pelagic species in the surveyed area.

Biomass indices are gathered in table 2.3.1. and 2.3.2. and figure 2.3.1. No estimate has been provided for mackerel according to the low level of TS and particular behaviour in the Bay of Biscay where it is scattered and mixed with soft plankton echoes.

Anchovy was present this year as an abundance index around the average on the serie, a bit more than 93 000 tonnes, including one fourth of this abundance in the surface layer.

Sardine was well present this year, mostly in coastal waters from the south until the North of the bay of Biscay. It was also spotted offshore (mainly in the Northern part), in lower quantities than anchovy, near the surface.

About other species, the main characteristic of this year is that mackerel was very present, along the shelfbreak in the South and all along the platform in the North part of the Bay of Biscay.

As previous years, horse mackerel was very rare, scattered along the shelf. Another particularity of this year is the presence of sprat in the river plumes, according to the fresh water discharges from the rivers.

	Classic	Surface	total
anchovy	68 710	25 144	93 854
sardine	366 378	41 363	407 740
sprat	44 651		44 651
mackerel	627 418	105 320	732 739
horse mackerel	33 471		33 471
blue whiting	51 430		51 430

Table 2.3.1. Acoustic biomass index for sardine and anchovy by strata during PELGAS13

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
anchovy	**113 120**	**105 801**	**110 566**	**30 632**	**45 965**	**14 643**	**30 877**	**40 876**	**37 574**	**34 855**	**86 354**	**142 601**	**186 865**	**93 854**
CV anchovy	*0.064*	*0.141*	*0.113*	*0.132*	*0.167*	*0.171*	*0.136*	*0.100*	*0.162*	*0.112*	*0.147*	*0.0774*	*0.0466*	*0.1282*
Sardine	**376 442**	**383 515**	**563 880**	**111 234**	**496 371**	**435 287**	**234 128**	**126 237**	**460 727**	**479 684**	**457 081**	**338 468**	**205 627**	**407 740**
CV sardine	*0.083*	*0.117*	*0.088*	*0.241*	*0.121*	*0.135*	*0.117*	*0.159*	*0.139*	*0.098*	*0.091*	*0.0699*	*0.0767*	*0.0738*
Sprat	**30 034**	**137 908**	**77 812**	**23 994**	**15 807**	**72 684**	**30 009**	**17 312**	**50 092**	**112 497**	**67 046**	**34 726**	**6 417**	**44 651**
CV sprat	*0.098*	*0.155*	*0.120*	*0.198*	*0.178*	*0.228*	*0.162*	*0.132*	*0.268*	*0.108*	*0.108*			*0.1992*
Horse mackerel	**230 530**	**149 053**	**191 258**	**198 528**	**186 046**	**181 448**	**156 300**	**45 098**	**100 406**	**56 593**	**11 662**	**61 237**	**7 435**	**33 471**
CV HM	*0.079*	*0.204*	*0.156*	*0.137*	*0.287*	*0.160*	*0.316*	*0.065*	*0.455*	*0.09*	*0.188*			*0.3007*
Blue Whiting	-	-	**35 518**	**1 953**	**12 267**	**26 099**	**1 766**	**3 545**	**576**	**4 333**	**48 141**	**11 823**	**68 533**	**25 715**
CV BW	-	-	*0.386*	*0.131*	*0.202*	*0.593*	*0.210*	*0.147*	*0.253*	*0.219*	*0.074*			*0.1542*

Table 2.3.2. Acoustic biomass index for the five main pelagic species since the beginning of PELGAS surveys (2000)

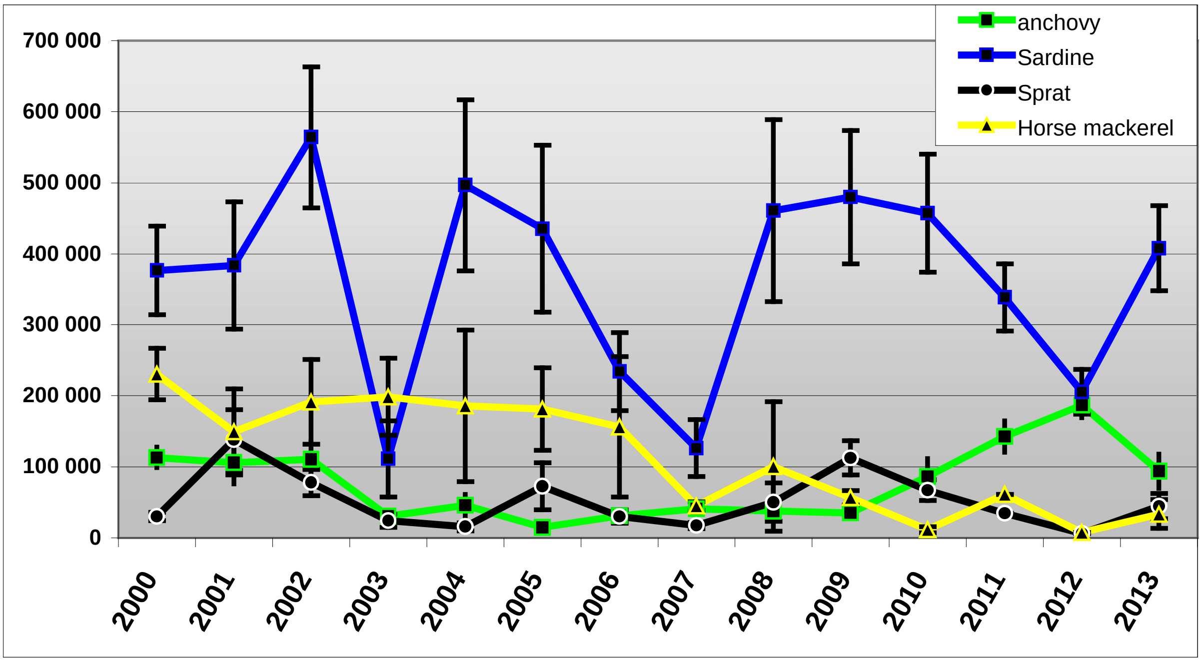


figure 2.3.1. – biomass estimate using Thalassa acoustic data along transects and all the consort identification fishing operations (Thalassa + pair trawlers) and coefficients of variation associated.

3. Anchovy data

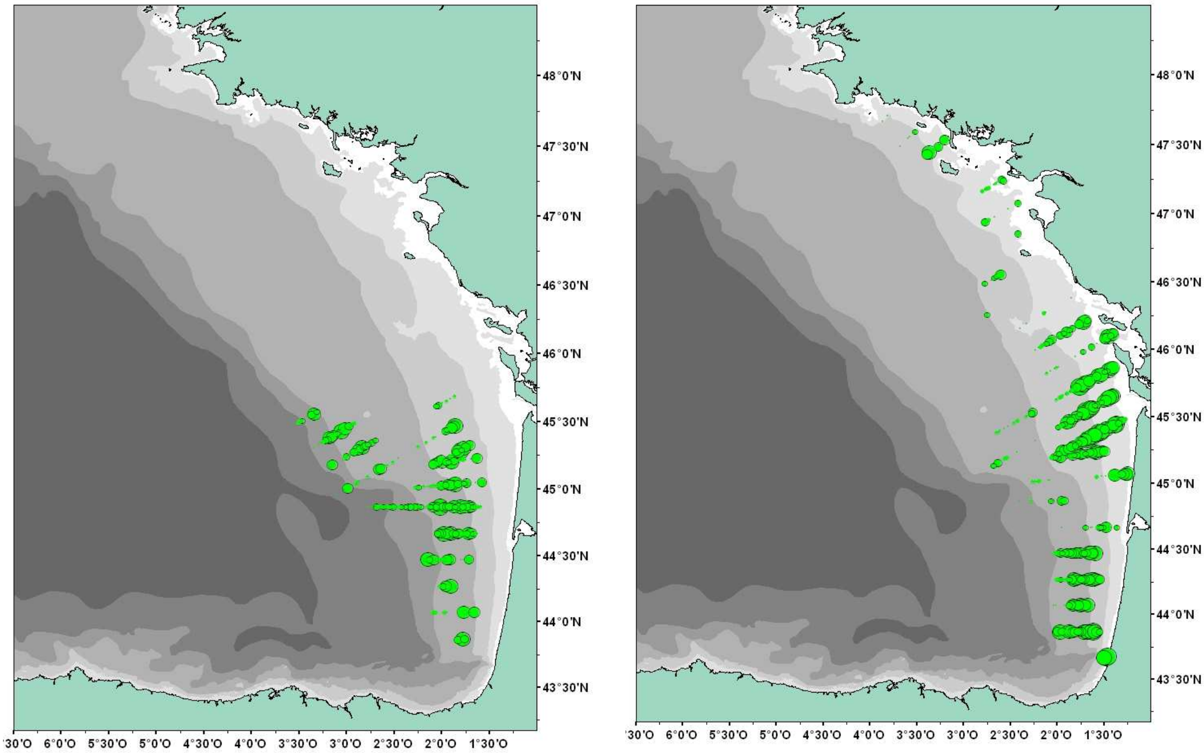
3.1. anchovy biomass

The main observation in 2013 is that anchovy was present in important densities at the shelfbreak, near the surface, as abundance in this layer never observed before. These echoes were systematically identified on each transect and revealed most of the time pure anchovy (the biggest individual this year) or at least a large majority of anchovy.

In the Gironde area, we found a configuration more classic (in size and in Sa), with an acoustic energy attributed to anchovy about the average, and far away from the very high energies from 2012. Nevertheless, anchovy was predominant in this area. The most part of the age 1 of anchovy was there, in size class comparable with a “normal” year (all, except 2012 where the fish was much smaller).

In the South part of the bay of Biscay, anchovy was also well present in the middle of the platform, in the whole water column (close to the bottom until the surface).

On the South coast of Britanny, little sightings of anchovy occurred around the Loire river.



Surface distribution

Classic distribution, between the bottom and 40m above

Figure 3.1. – Anchovy distribution according to PELGAS13 survey.

3.2. Anchovy length structure

Length distribution in the trawl haul were estimated from random samples. The population length distributions (figures 3.2.1 and 3.2.2) has been estimated by a weighted average of the length distribution in the hauls. Weights used are acoustic coefficients (Dev*Xe Moule in thousands of individuals per n.m.^{2}) which correspond to the abundance in the area sampled by each trawl haul.

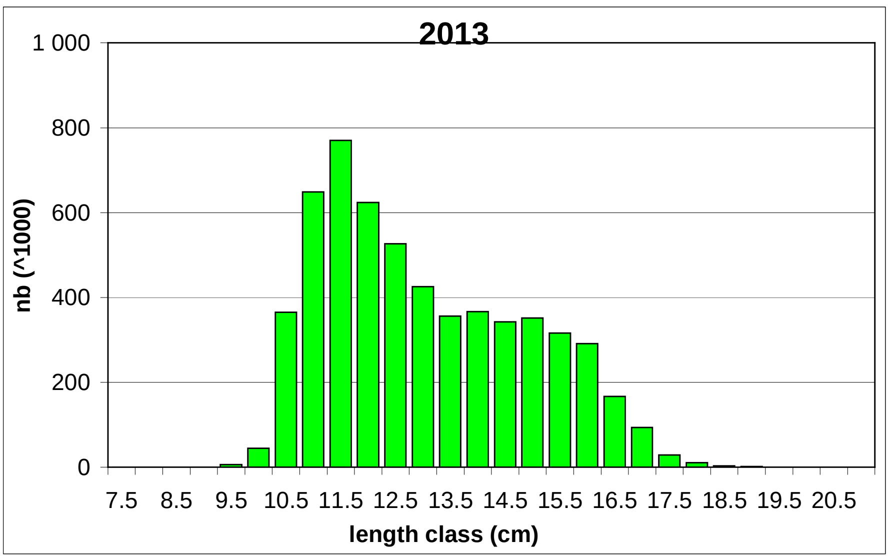


Figure 3.2.1: length distribution of global anchovy as observed during PELGAS13 survey

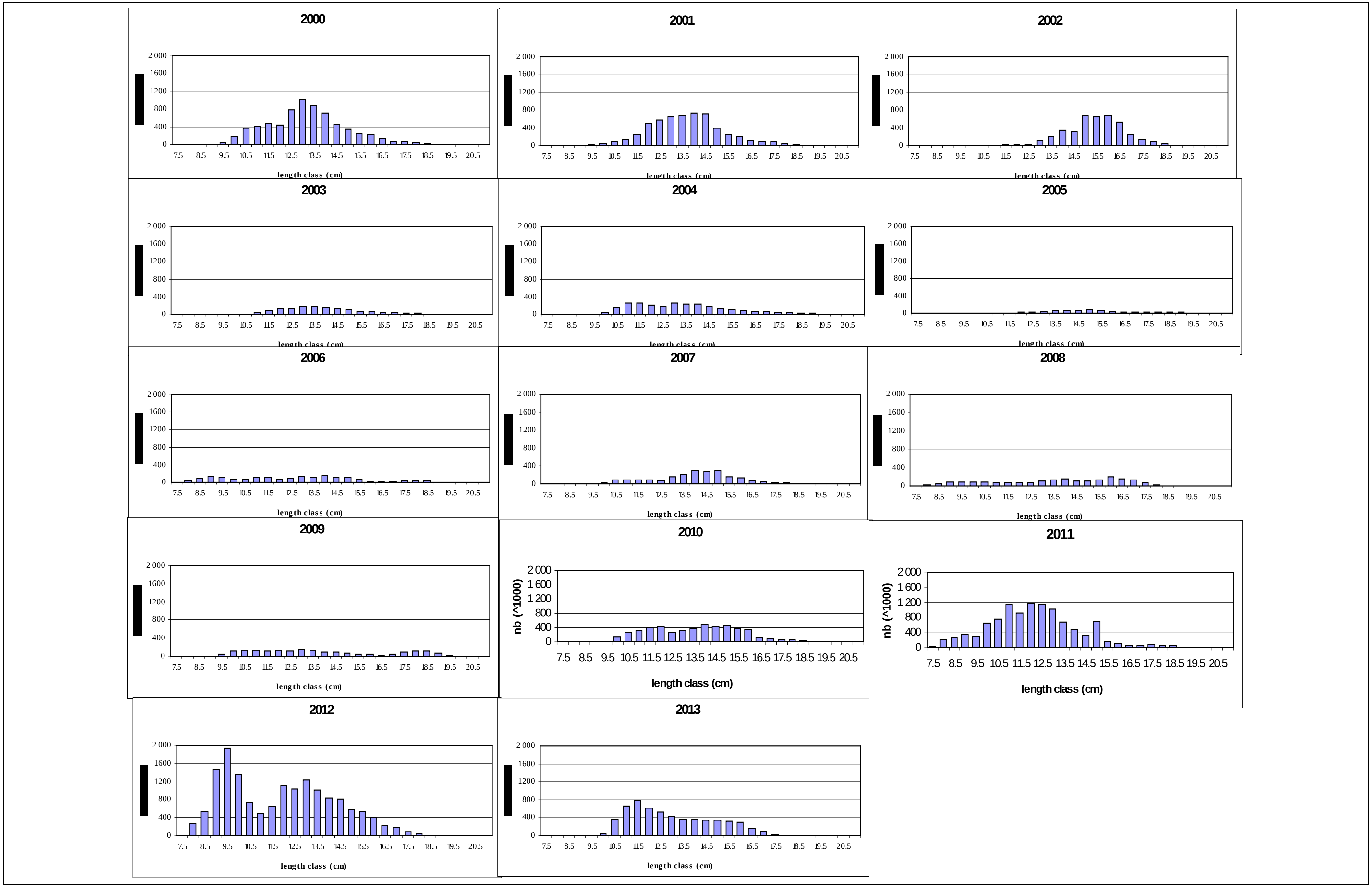


Figure 3.2.2. – length composition of anchovy as estimated by acoustics since 2000

. **3.3. Demographic structure**

An age length key was built for anchovy from the trawl catches (Thalassa hauls) and samples from commercial vessels. We took the otoliths from a set number of fishes per length class (4 to 6 /half-cm), for a total amount of around 50 fish per haul. As there was a lot of fishing operations where anchovy was present, the number of otoliths we took during the survey was more or less the same as the 3 last years (1248 otoliths read on board), The population length distributions were estimated by a weighted use of length distributions in the hauls, weighted as described in section 3.2.

Table 3.3.1. PELGAS13 anchovy Age/Length key.

taille (mm)	1	2	3	4	Total
85	100%				100%
90	100%				100%
95	100%				100%
100	92%	8%			100%
105	83%	17%			100%
110	86%	14%			100%
115	88%	10%	2%		100%
120	80%	20%			100%
125	73%	22%	5%		100%
130	76%	20%	5%		100%
135	61%	34%	5%		100%
140	53%	43%	4%		100%
145	35%	59%	7%		100%
150	20%	62%	18%		100%
155	5%	78%	17%		100%
160		73%	27%		100%
165	2%	74%	24%		100%
170		68%	32%		100%
175		53%	47%		100%
180		47%	53%		100%
185			100%		100%
190		100%			100%

Applying the age distributions to the abundance in biomass and numbers, the distribution in age of the biomass has been calculated. The total biomass used here has been updated with the value obtained from the previous method based on strata.

Age distribution is shown in figures 3.3.2. The age distributions compared from 2000 to 2012 are shown in figure 3.3.3.

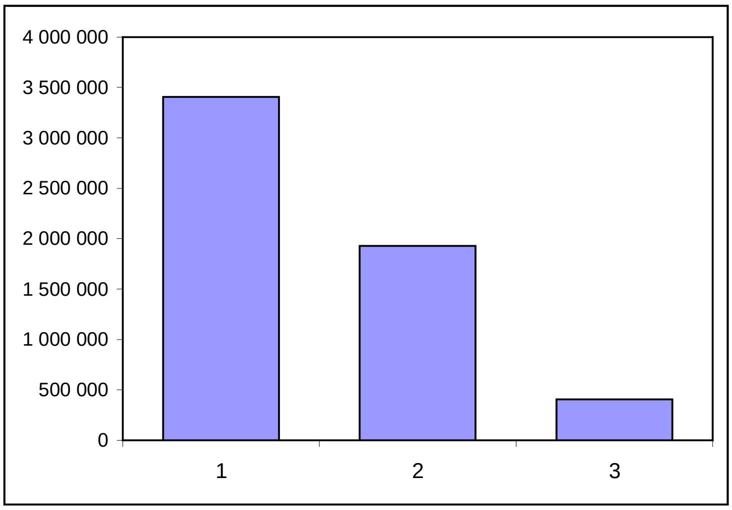


Figure 3.3.2– global age composition (numbers) of anchovy as observed during PELGAS13.

Looking at the numbers at age since 2000 (fig 3.3.3.), the number of 1 year old anchovies this year seems to be around the average of the serie, but far away from the two previous years level of recruitment.

The number of age 2 this year indicates maybe a light overestimate of the last year recruitment. But it must be noticed that the high densities and abundance of anchovy (mainly 2 years old) near the surface, thus in the blind layer of the Thalassa echo-sounders, lead probably to an underestimation of the age classes 2 and 3.

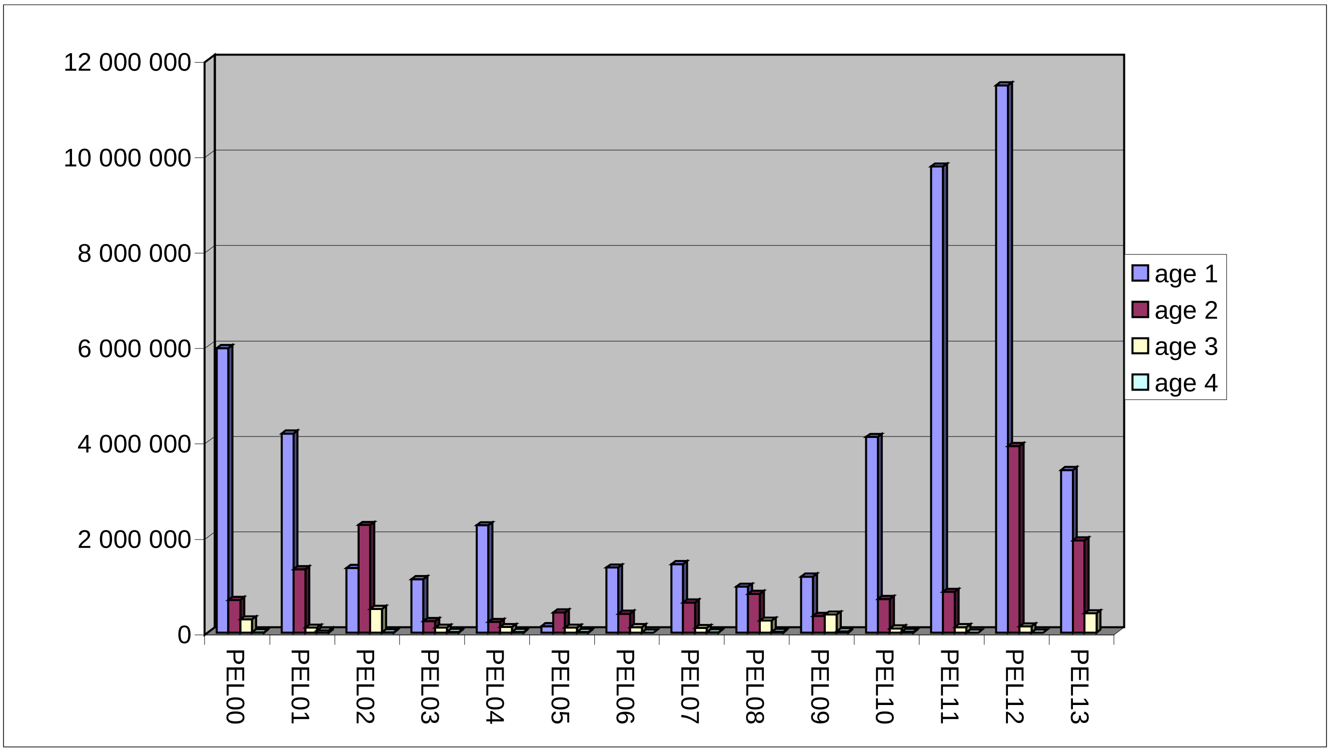


Figure 3.3.3 Anchovy numbers at age as observed during PELGAS surveys since 2000

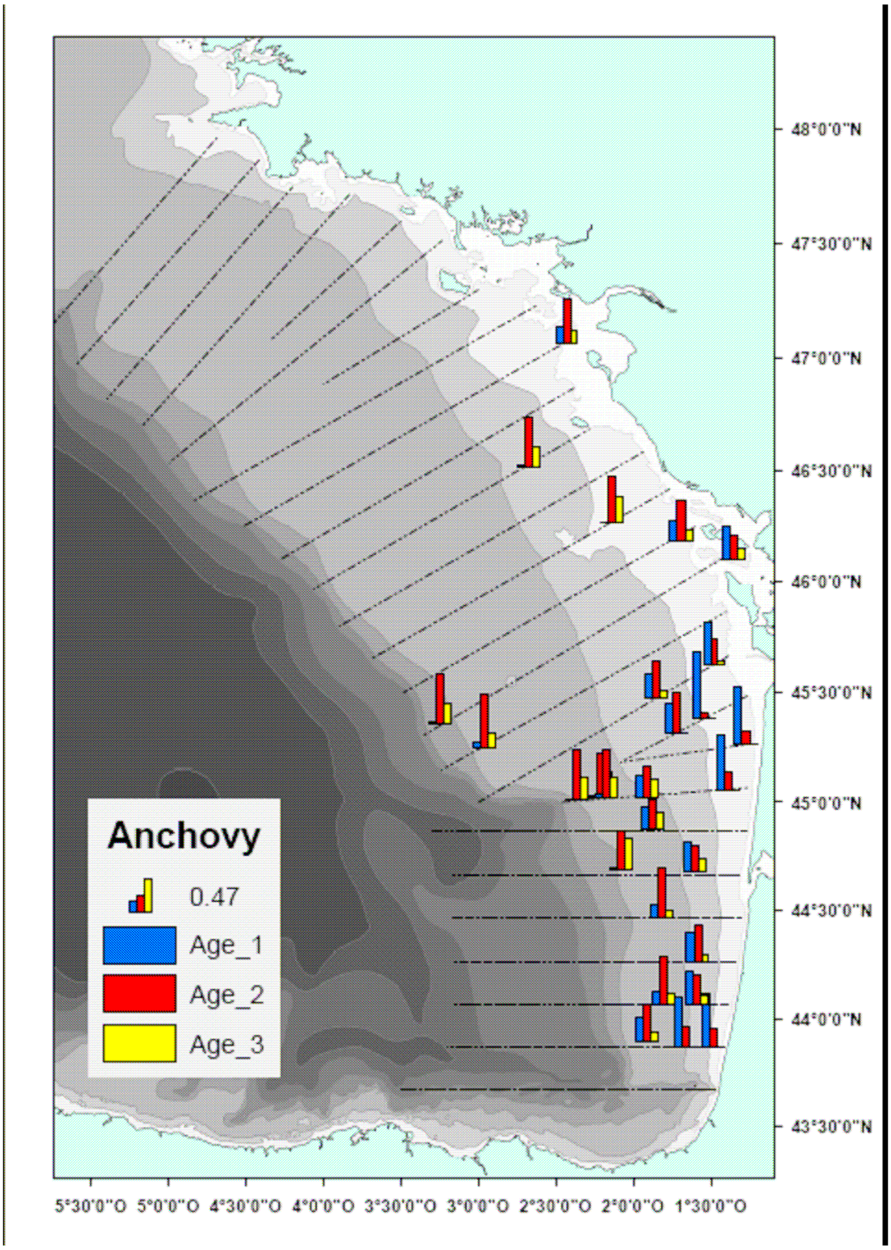


Figure 3.3.4 Anchovy proportion at age in each haul as observed during PELGAS13 survey.

During previous surveys, anchovy was well geographically stratified depending on the age (*see WD 2010, Direct assessment of small pelagic fish by the PELGAS10 acoustic survey, Masse J and Duhamel E.*). It is less true this year as age1 were as usual predominant in the Gironde area, but also dispersed on the platform, mixed with age 2. The surface anchovy, present at the shelfbreak in the area called “fer à cheval” was almost exclusively constituted by age 2 and 3. At least, no age 4 was observed this year, on 1248 otoliths read.

age	PEL13 % - nb
1	59.3
2	33.6
3	7.1
4	0

age	PEL13_%_W
1	45.29%
2	43.41%
3	11.30%
4	0.00%

Figure 3.3.5 percentage by age of the Anchovy population observed during PELGAS13 in numbers (left) and biomass (right).

3.4. Weight/Length key

Based on 1248 weights of individual fishes, the following weight/length key was established (figure 4.5.) :

W= 2E-06L$^{3.2645}$ with R2 = 0.9667 *(with W in grams and L in mm)*

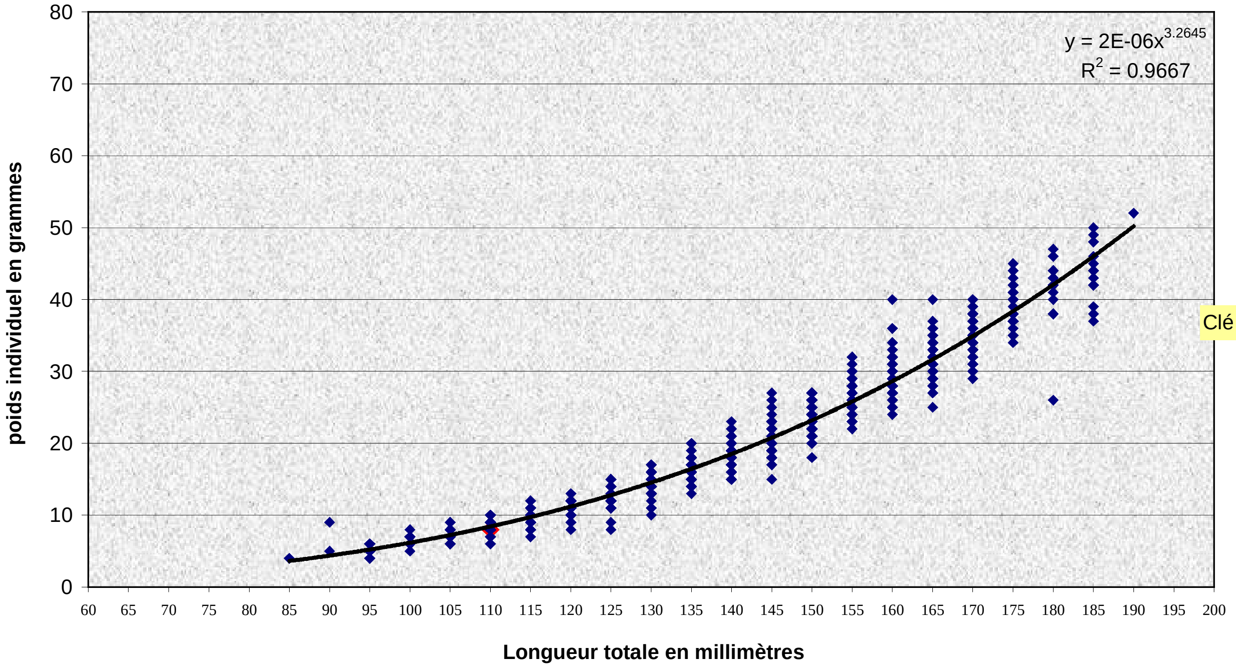


Fig. 3.4. – Weight/length key of anchovy established during PELGAS13

3.5. Mean Weigth at age

mean weigth at age (g)	AGE				
survey	1	2	3	4	5
PEL00	14.78	25.98	30.62	36.06	
PEL01	16.09	25.91	21.28	36.39	
PEL02	20.41	27.17	28.49	36.85	
PEL03	16.73	25.63	32.79	28.79	
PEL04	15.12	32.83	36.98	52.32	
PEL05	18.80	26.29	32.75	30.74	
PEL06	13.39	25.47	31.87	46.12	
PEL07	17.80	24.28	20.66		
PEL08	11.57	26.94	27.34	27.37	
PEL09	15.26	31.04	40.24	41.59	
PEL10	15.74	25.94	34.78	48.11	50.52
PEL11	11.33	27.13	26.02	60.54	
PEL12	7.72	19.70	20.85	35.36	
PEL13	12.61	21.34	26.46		

Fig. 3.5. – mean Weight at age (g) of anchovy for each PELGAS survey

3.6. Eggs

During this survey, in addition of acoustic transects and pelagic trawl hauls, 650 CUFES samples were collected and counted, 70 vertical plankton hauls and 73 vertical profiles with CTD were carried out. Eggs were sorted and counted during the survey.

This year was classical in terms of egg spatial distribution, with maximum for anchovy over the southern shelf, a few along the coast North of the Gironde, and no egg north of 46°N (fig 3.6.1).

Looking at the time series from 2000 to 2013 (Figure 3.6.2. and 3.6.3.), anchovy eggs abundance is above the average of the time series since 2000, but far away from the 2011 strong peak.

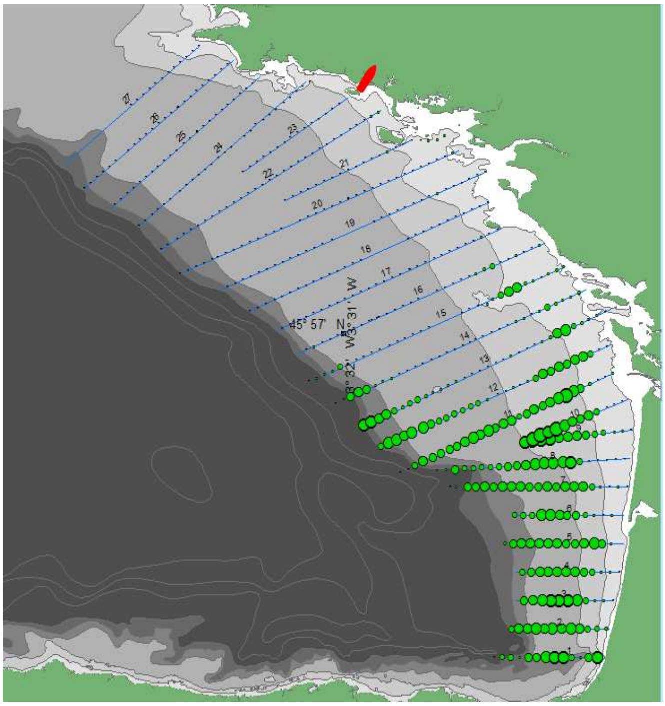


Figure 3.6.1 – Distribution of anchovy eggs observed with CUFES during PELGAS13.

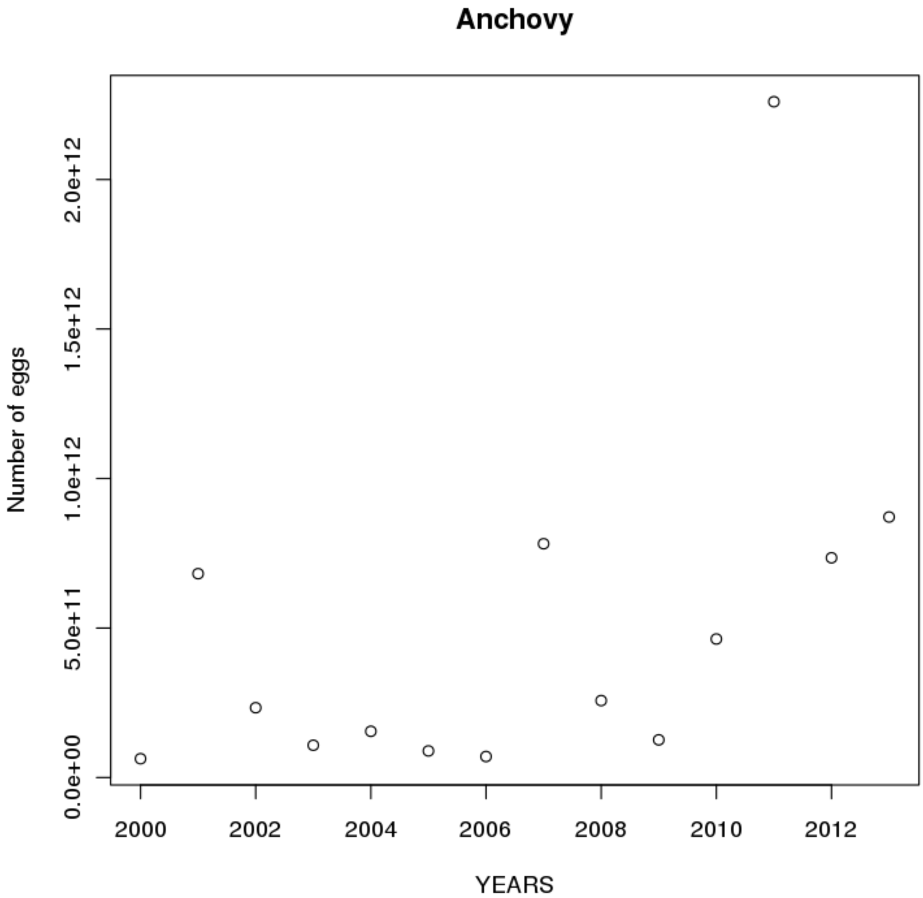


Figure 3.6.2 – Number of eggs observed during PELGAS surveys from 2000 to 2013

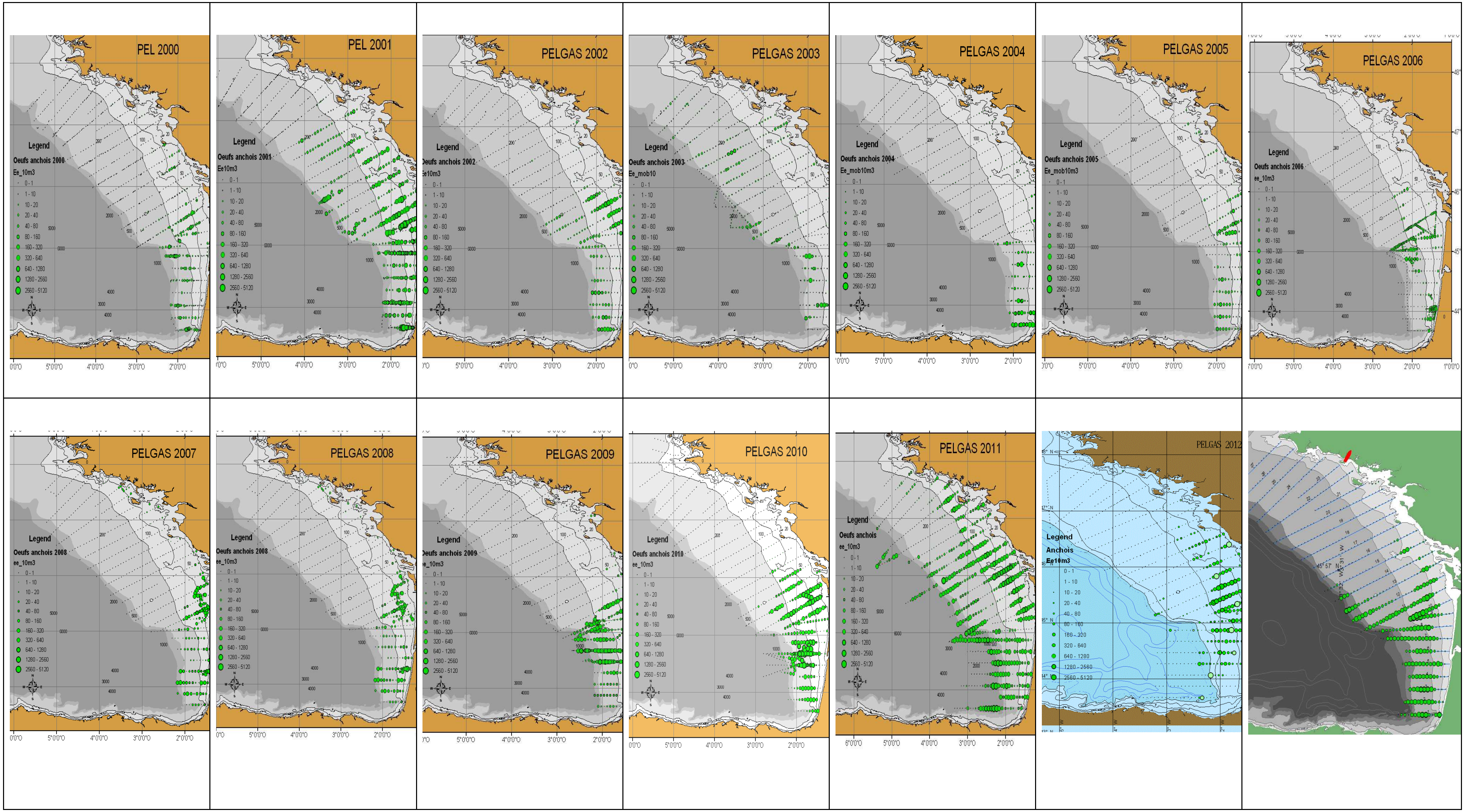


Figure 3.6.3 – distribution of anchovy eggs observed with CUFES during PELGAS from 2000 to 2013 (number for $10m^3$).

4. Sardine

4.1. Adults

The biomass estimate of sardine observed during PELGAS13 is **407 740** tons (table 2.3.), which is a bit upper than the average level of the PELGAS series, and constituting a new increase of the biomass. It must be enhance that these survey don't cover the total area of potential presence of sardine. It is possible that some years, this specie could be present up to the North, in the Celtic sea, SW of Cornouailles or Western Channel where some fishery occurs, apparently more and more. It is also possible that sometimes, a small fraction of the population could be present in very coastal waters, when the R/V Thalassa is unable to operate in those waters. The estimate is representative of the sardine present in the survey area at the time of the survey and can be therefore considered as an estimate of the Bay of Biscay (VIIIab) sardine population.

Sardine was distributed mixed with anchovy front of the Gironde (small fishes for both species) and mixed with sprat in the Loire plume. Then, sardine appeared pure along the Landes's coast, where a upwelling occured, due to the regular Northern wind. Sardine was also present close to the surface in the Northern part of the bay of Biscay, along the shelfbreak, sometimes mixed with mackerel.

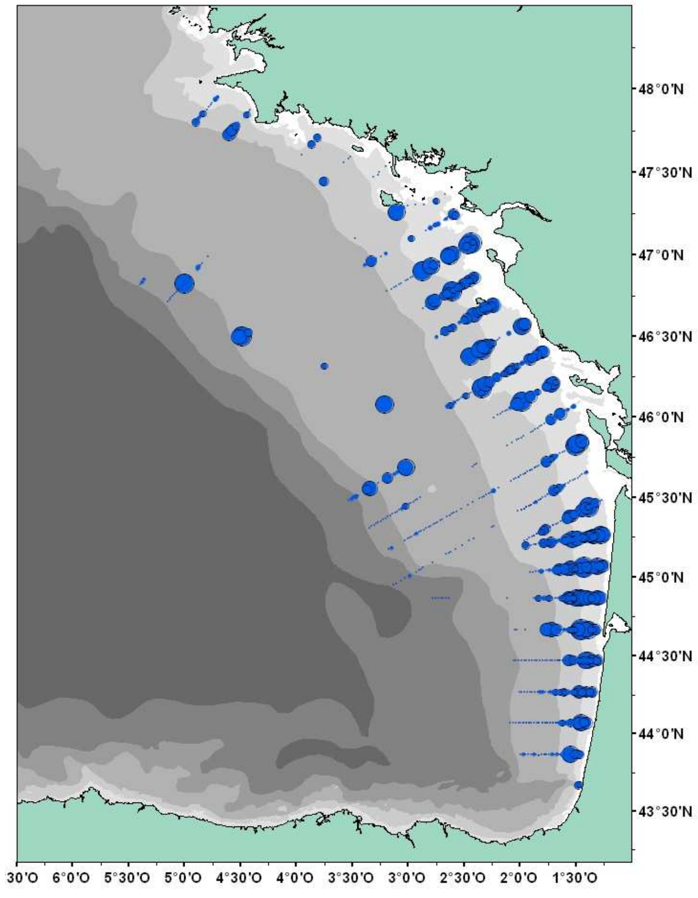


Figure 4.1.1 – distribution of sardine observed by acoustics during PELGAS13

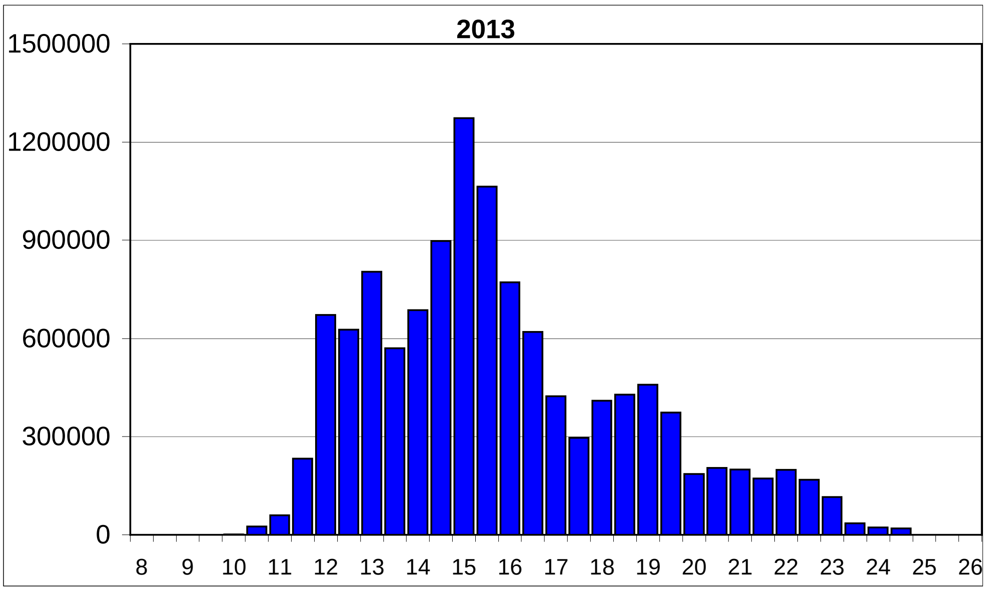


Figure 4.1.2. – length distribution of sardine as observed during PELGAS13

Length distributions in the trawl hauls were estimated from random samples. The population length distributions have been estimated by a weighted average of the length distribution in the hauls. Weights used are acoustic coefficients (Dev*Xe Moule in thousands of individuals per n.m.^{2}) which correspond to the abundance in the area sampled by each trawl haul. The global length distribution of sardine is shown on figure 4.1.2.

As usual, sardine shows a bimodal length distribution, the first one (about 15 cm, corresponding to the age 1, and very well present this year along the coast) and the second about 19 cm, which is mainly constituted by the 2 and 3 years old.

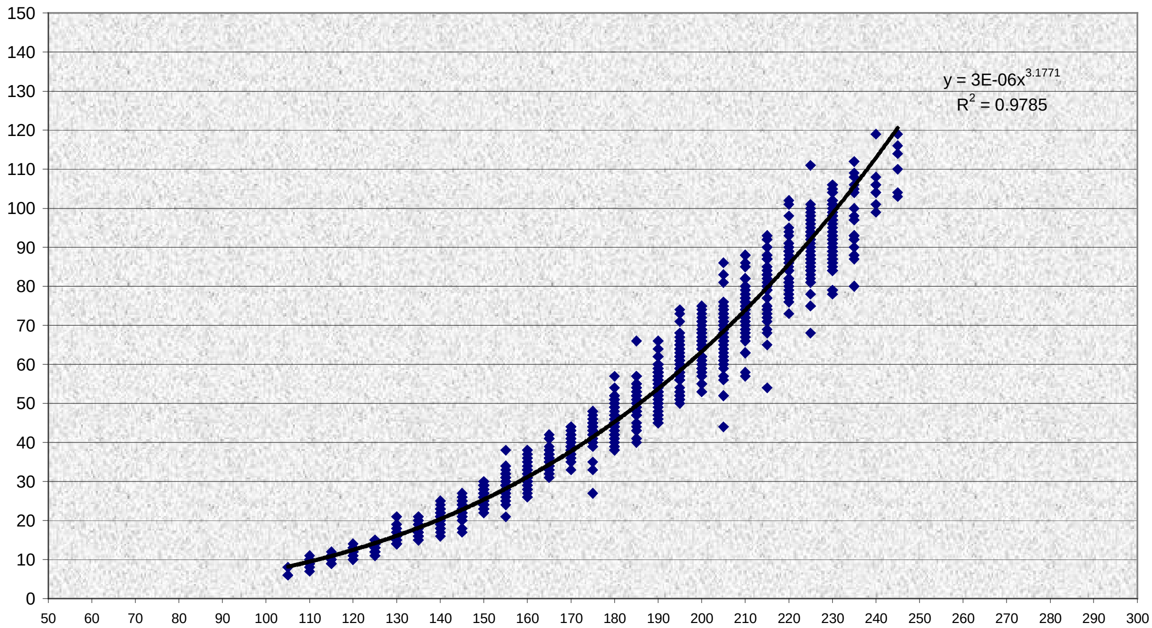


Figure 4.1.3 – Weight/length key of sardine established during PELGAS13

longueur (mm)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
85																	0%
90																	0%
95																	0%
100																	0%
105		100%															100%
110		100%															100%
115		100%															100%
120		100%															100%
125		100%															100%
130		100%															100%
135		100%															100%
140		100%															100%
145		98%	2%														100%
150		100%															100%
155		98%	2%														100%
160		90%	10%														100%
165		81%	19%														100%
170		47%	53%														100%
175		15%	85%														100%
180		5%	84%	11%													100%
185			77%	20%	3%												100%
190			62%	31%	4%	3%											100%
195		1%	44%	32%	12%	11%											100%
200			27%	31%	21%	17%	3%										100%
205			16%	25%	25%	27%	6%	2%									100%
210			7%	20%	26%	34%	11%	2%									100%
215				8%	17%	57%	15%	2%	2%								100%
220				2%	16%	53%	19%	7%	2%								100%
225					15%	44%	35%	2%			4%						100%
230					5%	46%	29%	12%	7%								100%
235					9%	52%	22%	9%		9%							100%
240						29%	29%	14%	29%								100%
245								17%	33%	50%							100%
250																	0%
255																	0%
260																	0%
265																	0%
Total		39%	23%	10%	7%	14%	5%	1%	1%	0%	0%						100%

Table 4.1.4 : sardine age/length key from PELGAS13 samples (based on 1310 otoliths)

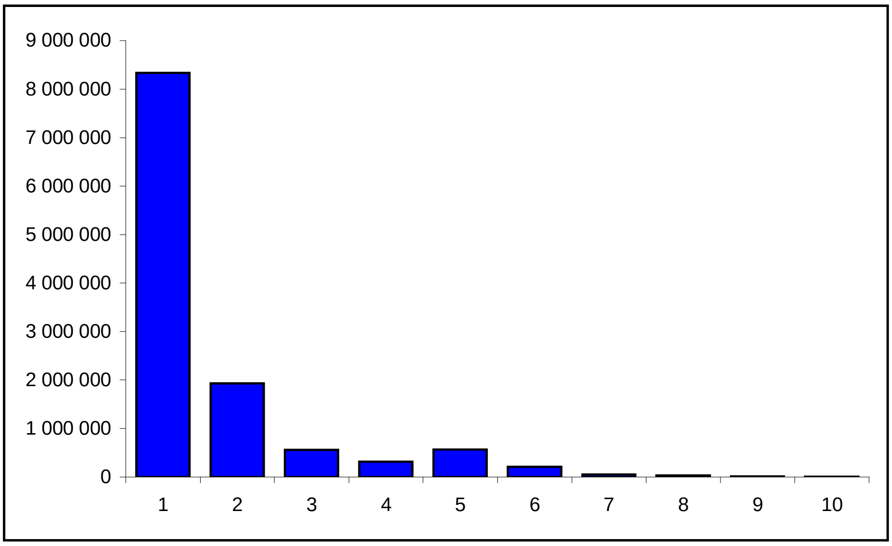


Figure 4.1.5.- Global age composition (nb) of sardine as observed during PELGAS 13

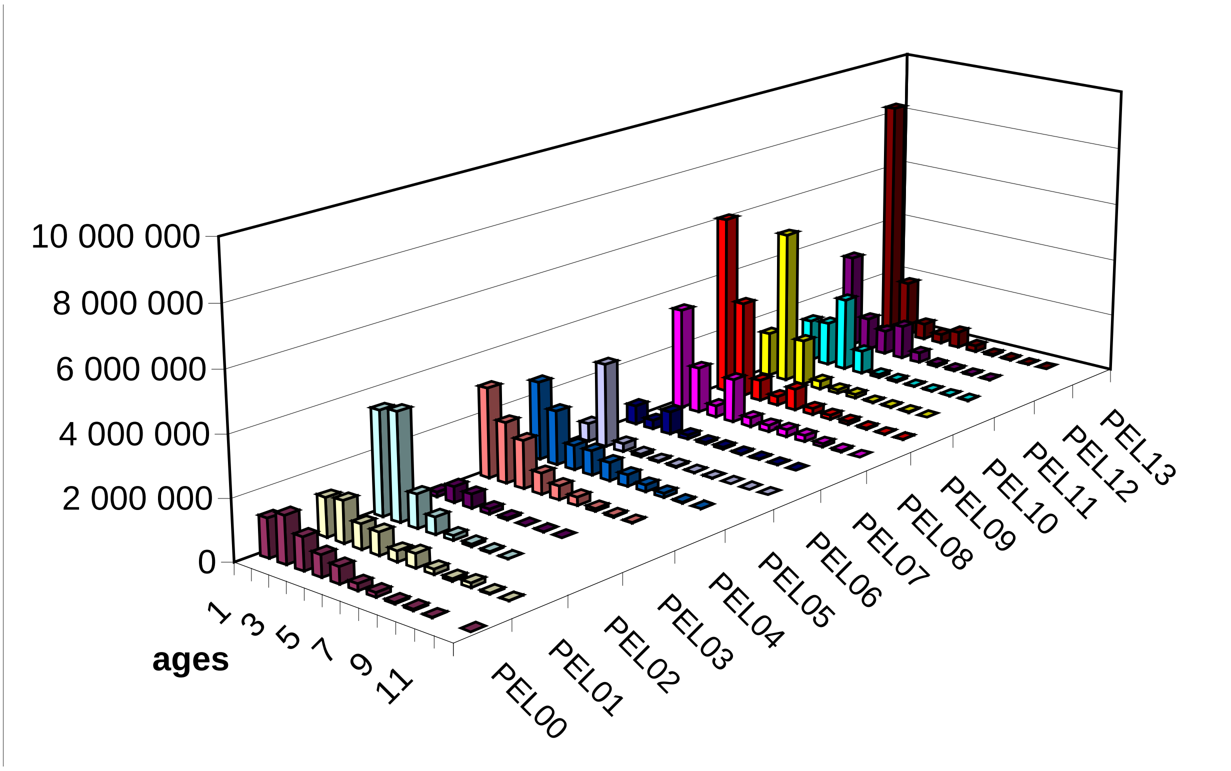


Figure 4.1.6- Age composition of sardine as estimated by acoustics since 2000

The series of age distribution in numbers since 2000 are shown in figure 4.1.6. We can observe that we can follow cohorts (i.e. the very low 2005 age class, or very high 2008 age class). 2003 and 2007 were atypical years in terms of environmental conditions and therefore fish (and particularly sardine) distributions.

The high abundance of age 1 (69% and 8 billions fishes) gives the impression that a very good recruitment occurred this year, maybe the best of the whole PELGAS serie.

	age									
survey	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
PEL00	35.05	54.74	69.15	76.46	84.82	89.93	98.83	110.18	105.04	112.87
PEL01	41.28	58.85	76.83	83.84	93.68	96.92	103.41	105.35	112.71	120.97
PEL02	40.48	60.2	74.94	81.7	92.31	99.42	106.68	118.05		
PEL03	53.35	68.04	73.15	78.11	86.04	93.33	88.74	96.09		
PEL04	35.94	64.73	76.54	84.39	95.87	98.83	104.34	109.19	106.15	
PEL05	34.44	63.45	73.29	79.62	84.88	88.96	90.04	105.42	109.45	98.35
PEL06	39.17	58.37	70.78	81.18	86.37	82.48	91.25	97.22	107.02	112.02
PEL07	37.55	65.96	71.77	79.05	84.02	94.45	100.37	96.93	101.27	114.86
PEL08	33.44	60.33	71.1	75.18	83.82	92.84	90.45	95.67	99.48	101.41
PEL09	29.51	57.13	73.62	81.28	83.26	88.35	95.67	91.44	96.50	106.67
PEL10	30.33	50.55	64.04	73.05	78.43	87.58	93.16	105.88	106.96	116.01
PEL11	27.37	50.13	58.69	69.84	78.35	83.00	84.28	108.17	105.38	108.33
PEL12	22.88	44.66	57.40	65.45	78.42	87.83	95.26	92.27	99.83	
PEL13	21.16	44.33	55.82	68.30	77.42	84.27	89.28	99.10	113.27	89.17

Figure 4.1.7- mean Weight at age (g) of anchovy for each PELGAS survey

4.2. Eggs

Sardine eggs were observed mainly along the coast between the 50 and the 100m isobaths, from the south of the bay of Biscay to the south of Brittany. Then, another lower concentration was visible along the end of the continental slope, northern than the “fer à cheval”, according to the presence of adults in surface.

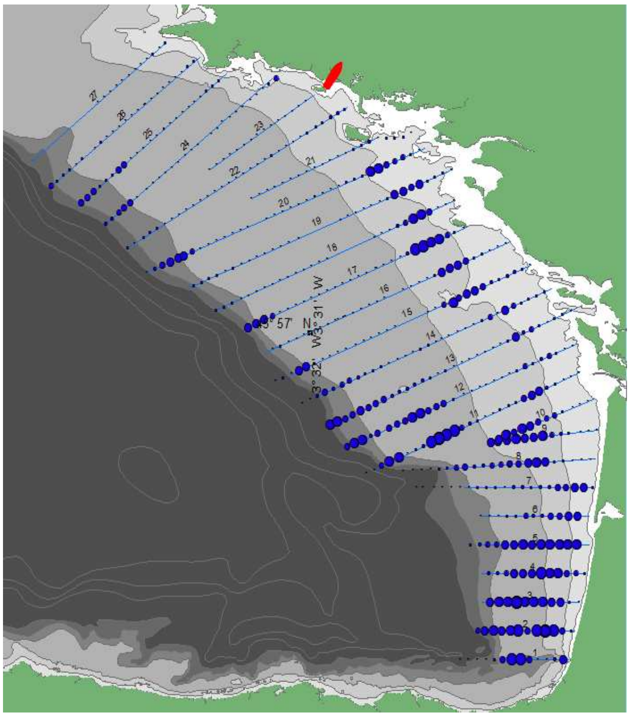


Figure 4.2.1. Distribution of sardine eggs observed with CUFES during PELGAS13.

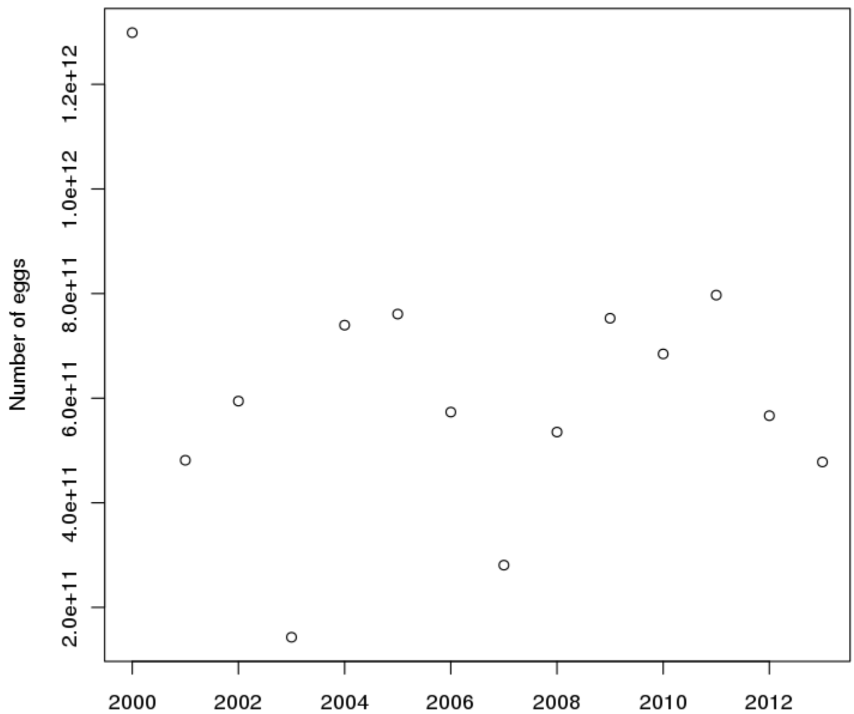


Figure 4.2.2. Number of eggs observed during PELGAS surveys from 2000 to 2013

The number of eggs collected by CUFES during the PELGAS13 survey was comparable to previous years but still far below the maximum observed in 2000.

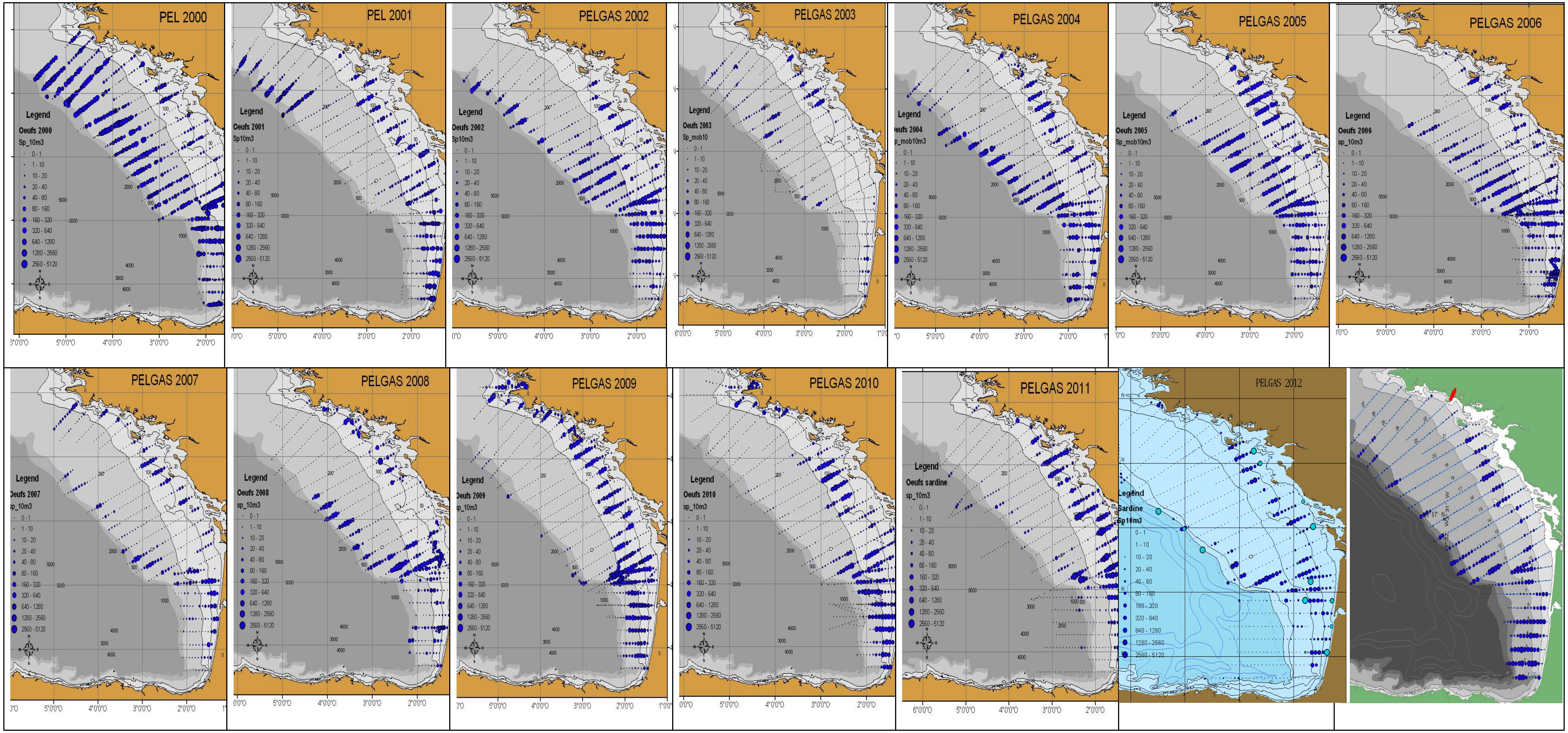
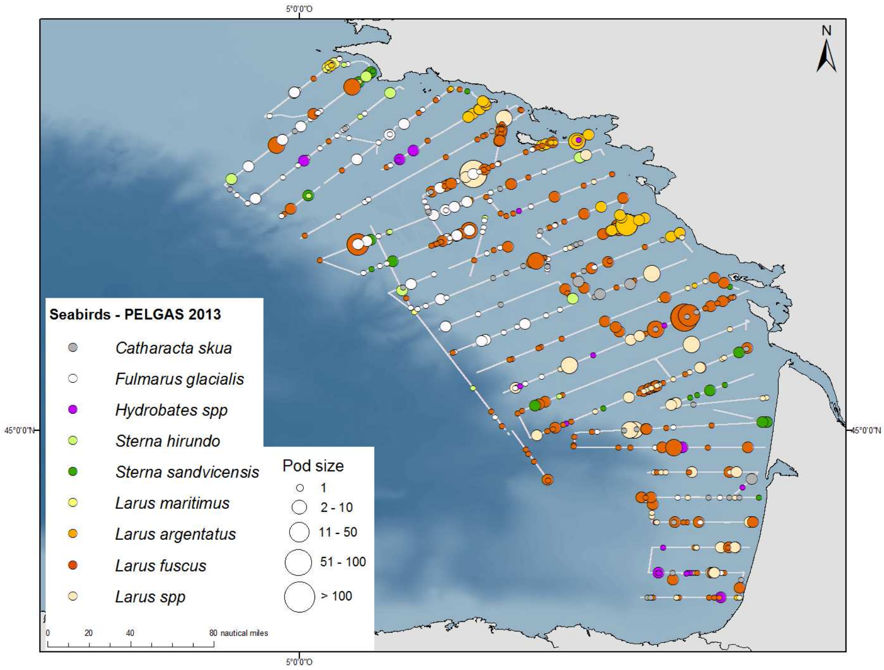


Figure 4.2.3 – distribution of sardine eggs observed with CUFES during PELGAS from 2000 to 2013 (number for 10m^3).

5. Top predators

5.1 – Birds



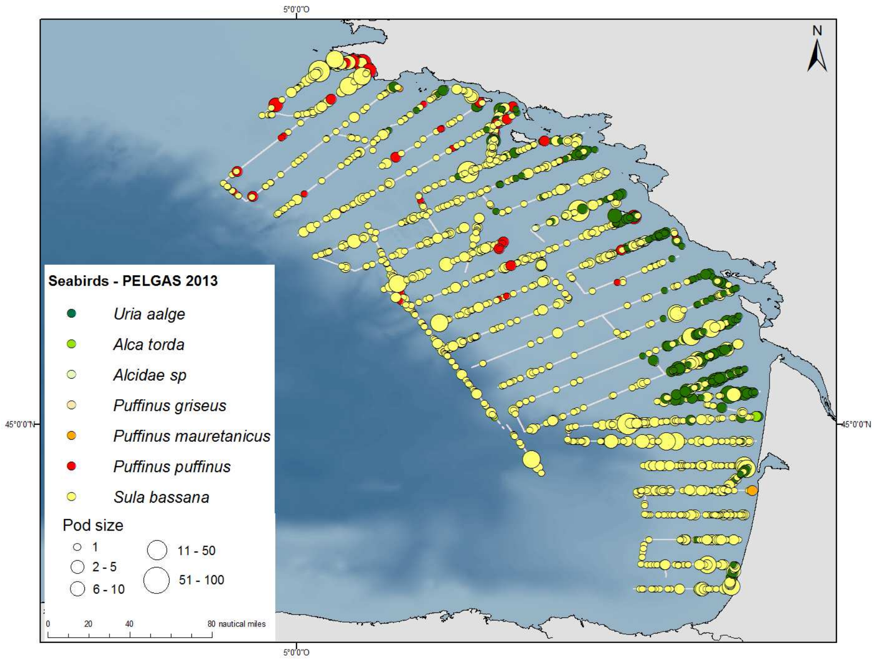


Figure 5.1.1 Distribution of surface (up) and diving (down) marine birds observed during the PELGAS13 survey

Birds constitute the main recorded sightings, however, should be separated marine species from other of shorebirds and passerines (3% of birds inventoried). 2982 sightings of seabirds were found all over the Bay of Biscay, divided into 24 species and 7664 individuals

Gannet sightings constitute 56% of seabirds recording. It's species that add the highest number of individuals. It presents a homogeneous distribution across the Bay of Biscay. Numerous individuals were seen close to Brittany and in front of Gironde estuary.

Second specie more observed is Guillemot. Alcids sightings represent 15% of seabirds and 797 individuals. Most of them are localized on the shelf in the Gironde estuary area.

Lesser Black-backed gull (9%) and other large gulls show 14% of seabirds sightings. Large pods with several hundred individuals were seen on the east part of the shelf. A few of them were seen in the south whereas an important fishing activity were recorded.

Great skuas, fulmars and Manx shearwater are other species also appearing in the sampling area but in lower quantities.

Seabirds sightings are substantially increased with nearly 3 000 records and 7 600 individuals. Gannets abundance could be the main reason, number of sighting is twice more important than last year. They were seen throughout the bay of Biscay and half of them were adults. Guillemot appears as a new frequent specie than usually, and most of sightings were localized in front of the Gironde estuary. Abundant in quantities, Larids were recorded with adult and immature black-backed gulls distributed in the northern half of the studied area.

Numerous seabirds have been observed this year, it could indicate various conditions. Generally, adult Gannets and Guillemots stay in the Bay of Biscay for wintering. Early in springtime, they join their breeding colonies in the North, out of this area. This abundance of seabirds seems to indicate conditions more close of wintertime than the springtime, but it need to confirm with hydrological data collected during the survey.

5.2 – Mammals

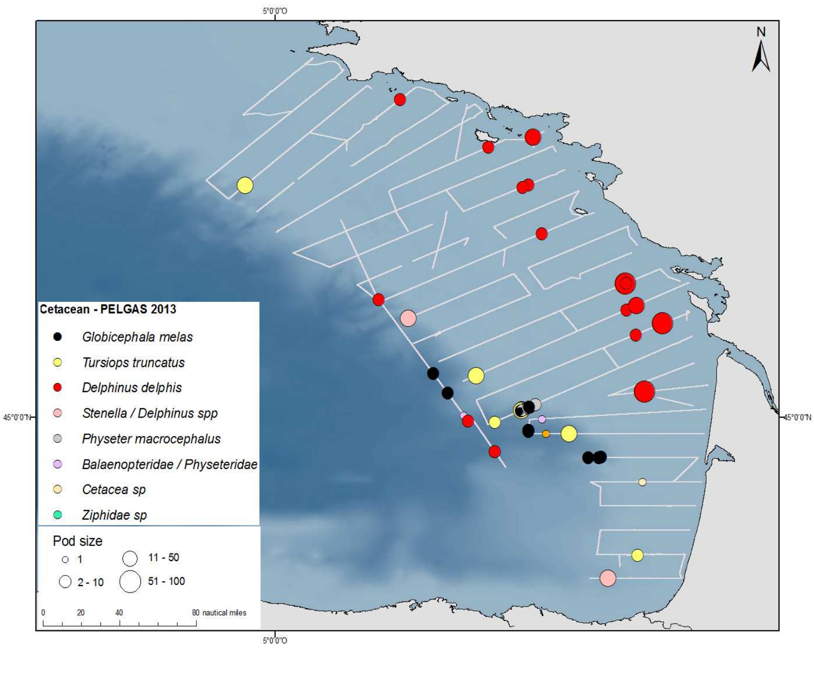


Figure 5.2.1 Distribution of mammals during the PELGAS13 survey.

A total of 50 sightings were recorded with 4 out of effort period (visual prospection) during trawling operations or hydrological stations. The total corresponds to an estimate of 610 individuals and 4 species of cetaceans clearly identified.

Common dolphin is the most recorded species (32% of cetacean sightings). Common dolphin shows a distribution on the inshore part of the continental shelf, this pattern is usual during springtime. Few sightings are localised in the slope to the southern bay of Biscay. Group size varies from 2 to 100 individuals.

Pilot whale appears very present (28%) with small pods recorded around the slope and canyons in the middle of the area. Bottlenose dolphins sightings are less regular (14%) and correspond to pods mainly located on the slope.

Pods of unidentified small dolphins relate mostly distant sightings, and it is highly probable that it is common or striped dolphin.

Large whales have been encountered this year only with sperm whales but no fin/minke whale. They were localised to the Cap Ferret canyon at the same place that a probable Cuvier's beaked whale.

Specific richness detected this year is relatively poor with four cetaceans identified. Very few marine mammals were seen in the northern part of the Bay of Biscay. General distribution shows a stronger presence of cetaceans in the slope middle-west notably Sperm whale and Pilot whale. Only Common dolphin was localised more on the inshore part of the continental shelf. Also absence of large whales (fin/minke) could be explained by less offshore observation effort. However, the general trend in the distribution pattern is similar than previous Pelgas surveys, only the northern part seems abnormally poor. Weather conditions in that area were not clearly limited, moreover sunfishes were observed. The presence of unusual military activities working with acoustics systems might be an explanation..

6. Hydrological conditions

After a relatively cold and wet winter, conditions have changed from early April to bad weather. We started the survey with cold and bad weather, and these conditions were predominant until the survey break on 24th of May, except 2or 3 days of good weather.

Temperature were about 2°C below the average temperature in May over the whole Bay of Biscay. Stratification was weak under low light availability and sustained wind, and actually more related to the cumulated freshwater discharged throughout winter. The latter also explained early blooms in late february, but no high chlorophyll biomass was observed during the survey.
The sustained wind from the North explained the occurrence of an upwelling with low temperature along the Landes's coast, potentially separating sardine and anchovy, the latter being more offshore in that specific area.

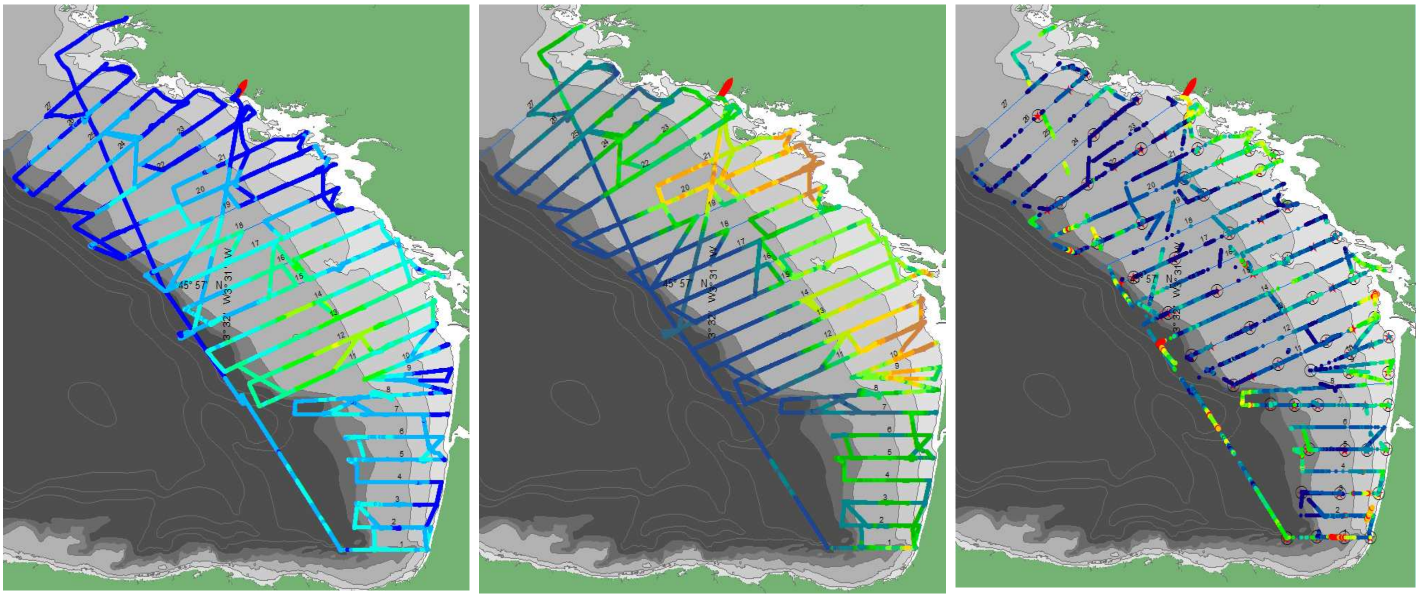


Figure 6.1. – Surface temperature, salinity and fluorescence observed during PELGAS13.

The medium river discharges during the spring (after a very wet winter) could be explained by the fact that the snow was still in the mountains during the survey's period

8. Conclusion

The Pelgas13 acoustic survey has been carried out with medium weather conditions (wind, cold temperatures) for the whole area, from the south of the bay of Biscay to the west of Brittany. The help of commercial vessels (two pairs of pelagic trawlers and a single one) during 18 days provided about 100 identification hauls as a whole instead of about 50 before 2007 when Thalassa was alone to identify echo traces. Their participation increased the precision of identification of echoes and some double hauls permitted to confirm that results provided by the two types of vessels (R/V and Fishing boats) were comparable and usable for biomass estimate purposes. These commercial vessels participated to the PELGAS survey in a very good spirit of collaboration, with the financial help of "France Filière Pêche" which is a groupment of French fishing organisations.

Temperature and salinity recorded during PELGAS13 were affected by rather bad weather conditions before and during the survey. During the whole survey, water column showed a lack of stratification, with a very low surface temperature (often 2°C below the average SST).

The PELGAS13 survey observed a medium abundance of anchovy (93 854 tons), far away the highest level observed on the time series (186 865 tons, last year). In the South, anchovy was mostly concentrated in the middle of the platform, and the small individuals as usual were mostly present in the Gironde area. Nevertheless, this year was particular in terms of a very important presence of anchovy offshore in the surface layer (between this one and 20 meters below). This configuration, never observed before in that quantity, lead probably to an underestimation of the age 2 and 3, predominant in this area.

The biomass estimate of sardine observed during PELGAS13 is 407 740 tons, which constitutes an increase of the last years level of biomass. It represents an high abundance, and the high abundance of age 1 (69% and 8 billions fishes) gives the impression that a very good recruitment occurred this year, maybe the best of the whole PELGAS serie. It must be noticed that the number of age 5 individuals this year is rather still important compared to ages 3, 4 and 6, and confirms (one more time) the very good recruitment of the 2008 year class and confirms also the age readings and the fact that we can follow sardine cohorts in the sardine population of the bay of Biscay. Geographical distribution looks as usual, with maximum again in the Centre of the bay, with extension to the North and the South both along the coast and, in less quantity, along the slope.

Concerning the other species, mackerel was well present this year, all along the shelfbreak and on the platform in the North part of the bay, while horse mackerel was still rather absent this year.

Working Document to WGHANSA, 23-28 June 2013, Bilbao (Vizcaya), Spain

Preliminary index of biomass of Bay of Biscay anchovy (*Engraulis encrasicolus*, L.) in 2013 applying the DEPM and sardine total egg abundance

by

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Abstract

The research survey BIOMAN 2013 for the application of the Daily Egg Production Method (DEPM) in the Bay of Biscay anchovy was conducted in May 2013 from the 9th to the 28th covering the whole spawning area of the species. Two vessels were used: the R/V Ramón Margalef to collect the plankton samples and the pelagic trawler Emma Bardán to collect the adult samples. The total area covered was 77,838Km^2 and the spawning area was 35,448Km^2. During the survey 551 vertical plankton samples were obtained, 1,222 CUFES samples and 30 pelagic trawls were performed, from which 22 contained anchovy and 21 of them were selected for the analysis, the other one was rejected due to the small amount of individuals in the sample.

No anchovy eggs were found in the Cantabrian Coast. The spawning area started at 43º45'N in the French platform and the northern limit was found at 46º15'N. The eggs in the French platform where encountered in the historical common places: Between Adour and Arcachon and in the area of influence of Le Gironde. The conditions of the survey were in general wintry, with a mean SST of 14.3ºC. The sampling was stopped for 12 hours due to bad weather at R 51. The cufes was broken and the sampling with cufes was stopped for 5 hours. Another cufes was then used at 4m. Moreover, the sampling was stopped during 40h at R 44 for refuel gas oleo.

Total egg production (P_{tot}) was calculated as the product of the spawning area and the daily egg production rate (P_0), which was obtained from the exponential decay mortality model fitted as a Generalized Linear Model (GLM) to the egg daily cohorts. The adult parameters, Sex Ratio, preliminary Batch Fecundity and Weight of mature females, were estimated based on the adult samples obtained during the survey and the Spawning frequency estimate was obtained as the mean of the historical series old and new. The index of biomass estimate taken the old series of S resulted in 65,909 t with a coefficient of variation of 16% and taken the new series of S resulted in 40,797t with a coefficient of variation of 16%. Until the implementation of the new series of S we adopted the index of biomass of **65,909t.** Total abundance of sardine was 5.5 E12 eggs, at levels of last year.

Introduction

Anchovy (*Engraulis encrasicolus*) is one of the commercial species of high economic importance in the Bay of Biscay. The economy of the Spanish purse seine fleets (primarily from the Basque Country, Cantabria and Galicia) and the French fleet rely greatly on this resource (Uriarte *et al*., 1996 and Arregi *et al*., 2004). In order to provide proper advice on the fishery management, it is necessary to conduct annually a monitoring of the population. Thanks to that monitoring, ICES (International Council for the Exploration of the Sea) recommended a limited TAC of 20,700 t for 2012.

Anchovy is a short-lived species, for which the evaluation of its biomass has to be conducted by direct assessment methods as the daily egg production method (DEPM) (Barange *et al*, 2009). This method consists of estimating the spawning stock biomass (*SSB*) as the ratio between the total daily egg production (P_{tot}) and the daily fecundity (*DF*) estimates. In consequence, this method requires a survey to collect anchovy eggs (plankton sampling) for estimating the P_{tot} and to collect anchovy adults (adult sampling) for estimating the *DF*. Since 1987, AZTI-Tecnalia (Marine and Food Technological Centre, Basque country, Spain), either alone or in collaboration with other institutes, has conducted annually specific surveys to obtain anchovy biomass indices (Somarakis *et al*., 2004; Motos *et al*., 2005, Santos *et al,* 2010). In addition, the Basque fishery on anchovy has been continuously monitored. This information has been submitted annually to ICES, to advice on the exploitation of the fishery.

The survey for the application of the DEPM to estimate the Bay of Biscay anchovy biomass is one of the two surveys which give information about the anchovy population. The other one carried out at the same time in May is the acoustic French survey. The biomass indices provided by the acoustic and DEPM surveys together with the information supplied by the fleet are used as input variables for a two stage biomass model used to assess the Bay of Biscay anchovy population (Ibaibarriaga *et al*., 2008). Apart from the anchovy SSB estimates the DEPM survey in the Bay of Biscay gives information on the distribution and abundance of sardine eggs and environmental conditions due to the recollection of different parameters in the area surveyed such as sea surface temperature, sea surface salinity, temperature and salinity in the water column, currents and winds.

This working document describes the BIOMAN2013 survey for the application of the DEPM for the Bay of Biscay anchovy in 2013. First, the data collection, the estimation of the total egg production and the reproductive parameters are described in detail. Then, the biomass index and the age structure of the population are given as they were used for the assessment and posterior management of this stock. Finally the historical trajectory of the population is reviewed.

Material and Methods

Survey description

The BIOMAN2013 survey was carried out in May, at the spawning peak covering the whole spawning area of anchovy in the Bay of Biscay. During the survey, icthyoplankton and adult samples were obtained for the estimation of total daily egg production and total daily fecundity respectively for anchovy. The age structure of the population was also estimated. In addition, extra plankton samples with the MIK net were collected to obtain jelly fish. Moreover, extra anchovy adults were taken for genetic analysis.

The collection of plankton samples was carried out on board R/V Ramón Margalef from the 9th to the 28th May. The area covered was the southeast of the Bay of Biscay (**Fig. 1**), which corresponds to the main spawning area and spawning season of anchovy. The sampling strategy was adaptive. The survey started from the West (transect 11, at 4º14’W), and covered the Cantabrian Coast eastwards up to Pasajes (transect 25, approx. 1º50’W) (**Fig. 1**) looking for the western limit of the spawning area. Then, the survey continued to the north, in order to find the Northern limit of the spawning area. When the egg abundances found were relatively high, additional transects separated by 7.5 nm were completed. This occurred from the Adour until Arcachon inside the 100m depth and the area of influence of Gironde. The sampling was stopped for 12 hours due to bad weather at R 51. Moreover the cufes was broken and the sampling with the cufes was stopped for 5 hours. Another cufes was then used at 4m instead to 3m. On the 19th the vessel stopped at port of Pasajes to take gas-oleo, in consequence the survey was stopped for 40h.

The strategy of egg sampling was identical to that used in previous years, i.e. a systematic central sampling scheme with random origin and sampling intensity depending on the egg abundance found (Motos, 1994). Stations were situated at intervals of 3 nmi along 15 nmi apart transects perpendicular to the coast.

At each station a vertical plankton haul was performed using a PairoVET net (Pair of Vertical Egg Tow, Smith *et al*., 1985 in Lasker, 1985) with a net mesh size of 150 µm for a total retention of the anchovy eggs under all likely conditions. The net was lowered to a maximum depth of 100 m or 5 m above the bottom in shallower waters. After allowing 10 seconds at the maximum depth for stabilisation, the net was retrieved to the surface at a speed of 1 m s^{-1}. A 45 kg depressor was used to allow for correctly deploying the net. "G.O. 2030" flowmeters were used to detect sequential clogging of the net during a series of tows.

Immediately after the haul, the net was washed and the samples obtained were fixed in formaldehyde 4% buffered with sodium tetra borate in sea water. After six hours of fixing, anchovy, sardine and other eggs species were identified, sorted out and counted on board. Afterwards, in the laboratory, a percentage of the samples were checked to assess the quality of the sorting made at sea. According to that, a portion of the samples were sorted again to ensure no eggs were left in the sample. In the laboratory, anchovy eggs were classified into morphological stages (Moser and Alshtrom, 1985). This year 1/5 of the samples were staged as well on board.

Sample depth, temperature, salinity and fluorescence profiles were obtained at each sampling station using a CTD RBR-XR420 coupled to the PairoVET. In addition, surface temperature and salinity were recorded in each station from the CT at 3m depth. At some points determinate before the survey, water was filtered from the surface to obtain chlorophyll samples to calibrate the chlorophyll data.

The Continuous Underway Fish Egg Sampler (CUFES, Checkley *et al*., 1997) was used to record the eggs found at 3m depth with a net mesh size of 350µm. The samples obtained were immediately checked under the microscope so that the presence/absence of anchovy eggs was detected in real time. When anchovy eggs were not found in six consecutive CUFES samples in the oceanic area transect was abandoned. The CUFES system had a CTD to record simultaneously temperature and salinity at 3 m depth, a flowmeter to measure the volume of the filtered water, a fluorimeter and a GPS (Geographical Position System) to provide sampling position and time. All these data were registered at real time using the integrated EDAS (Environmental Data Acquisition System) with custom software.

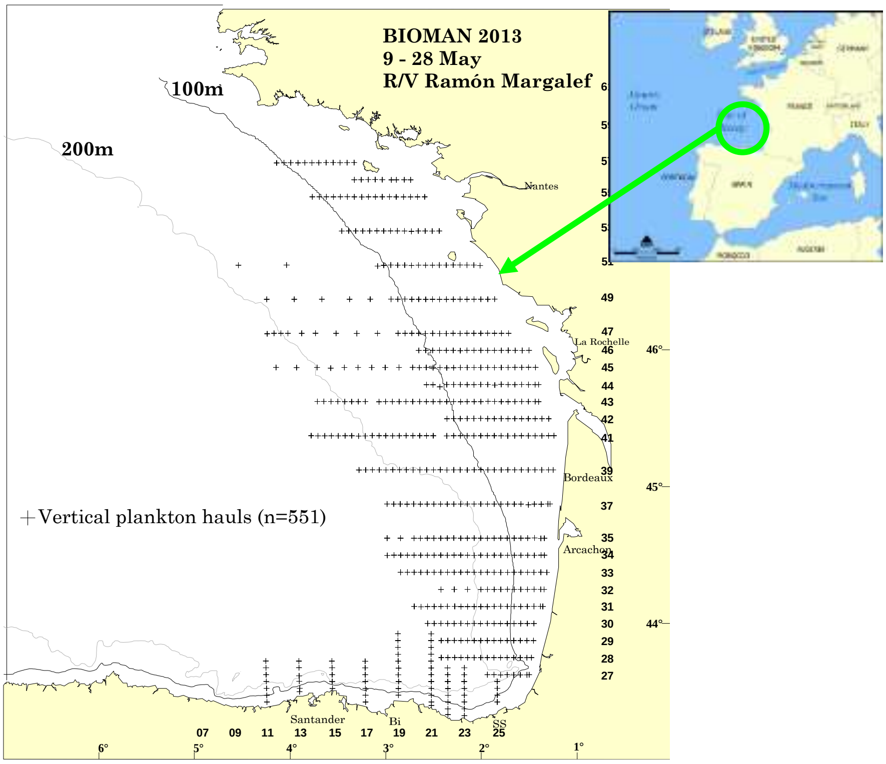

Figure 1: Plankton stations during BIOMAN 2013.

The adult samples were obtained on board R/V Emma Bardán (pelagic trawler) from the 8th to the 27th May coinciding in space and time with the plankton sampling. When the plankton vessel encountered areas with anchovy eggs, the R/V Emma Bardán was directed to those areas to fish. In each haul, immediately after fishing, anchovy were sorted from the bulk of the catch and a sample of two kg was selected at random. A minimum of one kg or 60 anchovies were weighted, measured and sexed and from the mature females the gonads of 25 non-hydrated females (NHF) were preserved. If the target of 25 NHF was not completed 10 more anchovies were taken at random and processed in the same manner. Sampling was stopped when 120 anchovies had to be sexed to achieve the target of 25 NHF. Otoliths were extracted onboard and read in the laboratory to obtain the age composition per sample. In addition, a piece of each anchovy was frozen to do genetic analysis afterwards on land. In each haul 100 individuals of each species were measured.

This year no additional anchovy adult samples were obtained from the commercial Basque purse seine fleet due to bad weather the week when the egg sampling was crossing the area of Cap Breton where the purse seiners were operating. The spatial distribution of the pelagic hauls with anchovy is shown in **Figure 2**.

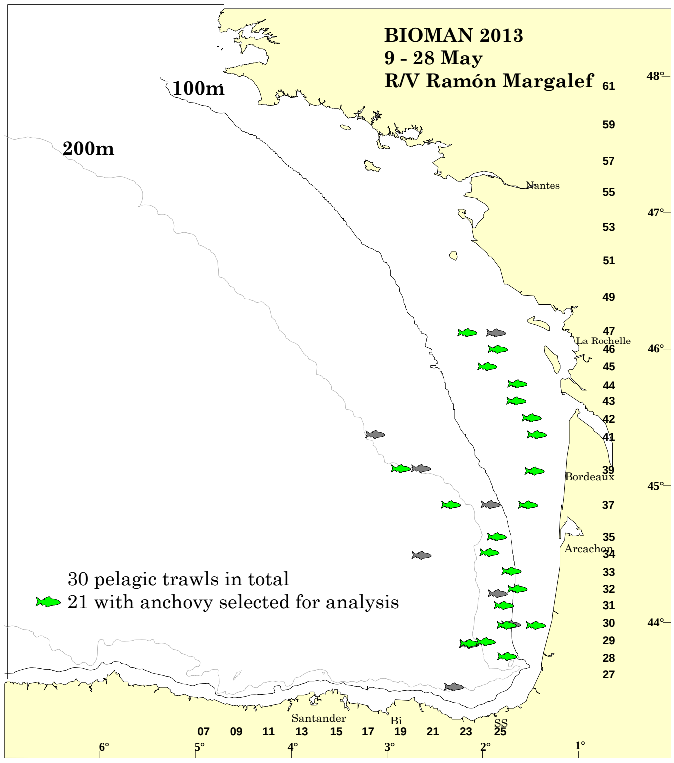

Figure 2: Spatial distribution of fishing hauls from R/V Emma Bardán in 2013.

Total egg production

Total daily egg production (P_{tot}) was calculated as the product between the spawning area (SA) and the daily egg production (P_0) estimates:

(1) $$P_{tot} = P_0 \, SA .$$

A standard PairoVET sampling station represented a surface of 45 Nm^2 (i.e. 154 km^2). Since the sampling was adaptive, the area represented by each station was corrected according to the sampling intensity and the cut of the coast. The total area was calculated as the sum of the area represented by each station. The spawning area (*SA*) was delimited with the outer zero anchovy egg stations although it could contain some inner zero anchovy egg stations embedded. The spawning area was computed as the sum of the area represented by the stations within the spawning area.

The daily egg production per area unit (P_0) was estimated together with the daily mortality rate (Z) from a general exponential decay mortality model of the form:

$$P_{i,j} = P_0 \exp\left(-Z\, a_{i,j}\right), \tag{2}$$

where $P_{i,j}$ and $a_{i,j}$ denote respectively the number of eggs per unit area in cohort j in station i and their corresponding mean age. Let the density of eggs in cohort j in station i, $P_{i,j}$, be the ratio between the number of eggs $N_{i,j}$ and the effective sea area sampled R_i (*i.e.* $P_{i,j} = N_{i,j} / R_i$). The model was written as a generalised linear model (GLM, McCullagh and Nelder, 1989; ICES, 2004) with logarithmic link function:

$$\log\left(E[N_{i,j}]\right) = \log(R_i) + \log\left(P_0\right) - Z\, a_{i,j}\ , \tag{3}$$

where the number of eggs of daily cohort j in station i (N_{ij}) was assumed to follow a negative binomial distribution. The logarithm of the effective sea surface area sampled ($\log(R_i)$) was an offset accounting for differences in the sea surface area sampled and the logarithm of the daily egg production $\log(P_0)$ and the daily mortality Z rates were the parameters to be estimated.

The eggs collected at sea and sorted into morphological stages had to be transformed into daily cohort frequencies and their mean age calculated in order to fit the above model. For that purpose the Bayesian ageing method described in ICES (2004), Stratoudakis *et al*., (2006) and Bernal *et al.*, (2011) was used. This ageing method is based on the probability density function (pdf) of the age of an egg *f(age* | *stage, temp)*, which is constructed as:

$$f\,(age\,|\,stage, temp) \propto\; f\,(stage\,|\,age, temp)\, f\,(age)\,. \tag{4}$$

The first term *f(stage* | *age, temp)* is the pdf of stages given age and temperature. It represents the temperature dependent egg development, which is obtained by fitting a multinomial model like extended continuation ratio models (Agresti, 1990) to data from temperature dependent incubation experiments (Ibaibarriaga *et al.*, 2007, Bernal *et al.*, 2008). The second term is the prior distribution of age. A priori the probability of an egg that was sampled at time τ of having an age *age* is the product of the probability of an egg being spawned at time τ - *age* and the probability of that egg surviving since then (*exp(-Z age)*):

$$(5) \qquad f(age) \propto f(spawn = \tau - age)\exp(-Z\,age)\ .$$

The pdf of spawning time *f(spawn=*τ *- age)* allows refining the ageing process for species with spawning synchronicity that spawn at approximately certain times of the day (Lo, 1985a; Bernal *et al*., 2001). Anchovy spawning time was assumed to be normally distributed with mean at 23:00h GMT and standard deviation of 1.25 (ICES, 2004). The peak of the spawning time was also used to define the age limits for each daily cohort (spawning time peak plus and minus 12 hours). Details on how the number of eggs in each cohort and the corresponding mean age are computed from the pdf of age are given in Bernal *et al* (2011). The incubation temperature considered was the one obtained from the CTD at 10m in the way down.

Given that this ageing process depends on the daily mortality rate which is unknown, an iterative algorithm in which the ageing and the model fitting are repeated until convergence of the *Z* estimates was used (Bernal *et al.*, 2001; ICES, 2004; Stratoudakis *et al.*, 2006). The procedure is as follows:

Step 1. Assume an initial mortality rate value

Step 2. Using the current estimates of mortality calculate the daily cohort frequencies and their mean age.

Step 3. Fit the GLM and estimate the daily egg production and mortality rates. Update the mortality rate estimate.

Step 4. Repeat steps (1)-(3) until the estimate of mortality converged (i.e. the difference between the old and updated mortality estimates was smaller than 0.0001).

Incomplete cohorts, either because the bulk of spawning for the day was not over at the time of sampling, or because the cohort was so old that its constituent eggs had started to hatch in substantial numbers, were removed in order to avoid any possible bias. At each station, younger cohorts were dropped if they were sampled before twice the spawning peak width after the spawning peak and older cohorts were dropped if their mean age plus twice the spawning peak width was over the critical age at which less than 99% eggs were expected to be still unhatched. In addition, eggs younger than 4 hours and older than 90% of the survey incubation time (Motos, 1994) were removed.

Once the final model estimates were obtained the coefficient of variation of P_0 was given by the standard error of the model intercept (log *(*P_0*)*) (Seber, 1982) and the coefficient of variation of Z was obtained directly from the model estimates.

The analysis was conducted in R (www.r-project.org). The ”MASS” library was used for fitting the GLM with negative binomial distribution and the ”egg” library (http://sourceforge.net/projects/ichthyoanalysis/) for the ageing and the iterative algorithm .

Daily fecundity

The daily fecundity (DF) is usually estimated as follows:

(6) $$DF = \frac{R \cdot F \cdot S}{W_f} \ ,$$

where R is the sex ratio in weight, F is the batch fecundity (eggs per batch per female weight), S is the spawning frequency (percentage of females spawning per day) and W_f is the female mean weight.

From 1987 to 1993 the **sex ratio (*R*)** in numbers resulted to be not significantly different from 50%. Therefore, since 1994 the sex ratio in numbers is assumed to be 0.5 and the sex ratio in weight per sample is estimated as the ratio between the average female weight and the sum of the average female and male weights of the anchovies in each of the samples.

A linear regression model between total weight (W) and gonad free weight (W_{gf}) was fitted to data from non-hydrated females:

(7) $$E[W] = a + b * W_{gf} \ .$$

This model was used to correct the weight increase of hydrated anchovies. **The female mean weight (*W_f*)** per sample was calculated as the average of the individual female weights.

For the **batch fecundity (*F*)** a preliminary estimate was achieve selecting the hydrated females a visu. 104 female were selected in that manner, from which 94 were retained after discarded the ones that presumably have POFs. On those females the hydrated egg method was followed (Hunter and Macewicz., 1985). The number of hydrated oocytes in gonads of a set of hydrated females was counted. This number was deduced from a sub-sampling of the hydrated ovary. Three pieces of approximately 50 mg were removed from the extremes and the centre of one of the ovary lobule of each hydrated anchovy. Those were weighted with precision of 0.1 mg and the number of hydrated oocytes counted. Finally the number of hydrated oocytes in the sub-sample was raised to the gonad weight of the female according to the ratio between the weights of the gonad and the weight of the sub-samples

The model between the number of hydrated oocytes and the female gonad free weight was fitted as a Generalized Linear Model with Gamma distribution and identity link:

(8) $$E[F] = a + b * W_{gf} \ .$$

The average of the batch fecundity for the females of each sample as derived from the gonad free weight - eggs per batch relationship was then used as the sample estimate of batch fecundity.

Once sex ratio, female mean weight and batch fecundity were estimated per sample, overall mean and variance for each of these parameters were estimated following equations for cluster sampling (Picquelle & Stauffer, 1985):

(9) $$y = \frac{\sum_{i=1}^{n} M_i y_i}{\sum_{i=1}^{n} M_i}$$ and

(10) $$Var(y) = \frac{n \sum_{i=1}^{n} M_i^2 (y_i - y)^2}{\left(\frac{\sum_{i=1}^{n} M_i}{n} \right)^2 n(n-1)} \ ,$$

where *Yi* and *Mi* are the mean of the adult parameter *Y* and the cluster sample size in sample *i* respectively. The variance equation for the batch fecundity was corrected according to Picquelle and Stauffer (1985) in order to account for the additional variance due to model fitting.

The weights *Mi* were taken to reflect the actual size of the catch and to account for the lower reliability when the sample catch was small (Picquelle and Stauffer, 1985). For the estimation of *W* and *F* when the number of mature females per sample was less than 20 the weighting factor was equal to the number of mature females per sample divided by 20, otherwise it was set equal to 1. In the case of R when the total weight of the sample was less than 800 g then the weighting factor was equal to the total weight of the sample divided by 800g, otherwise it was set equal to 1.

The estimation process of the **spawning frequency (*S*)** parameter was recently revised (Uriarte *et al*, 2012). This year we included the index of biomass with the average of the new historical series of S and with the old historical series of S. This year as in previous ones, the index of biomass adopted was the one with the spawning frequency as the average of the old historical series until de new stock annex is approval.

SSB and numbers at age

The Spawning Stock Biomass (*SSB*) was estimated as the ratio between the total egg production (P_{tot}) and daily fecundity (*DF*) estimates and its variance was computed using the Delta method (Seber, *1982*).

To deduce the numbers at age 4 regions, North (N), Gironde (G), South (S) and West (W) were defined depending on the distribution of the adult samples (size, weight and age) and the distribution of anchovy eggs (Figure 3). Mean and variance of anchovy mean weights and proportions at age in the adult population were computed as a weighted average of the mean weight and age composition per samples (equations 9 and 10) where the weights were proportional to the population (in numbers) in each region. In particular, the weighting factors were proportional to the egg abundance divided by the numbers of adult samples in the region and the mean weight of anchovy per sample.

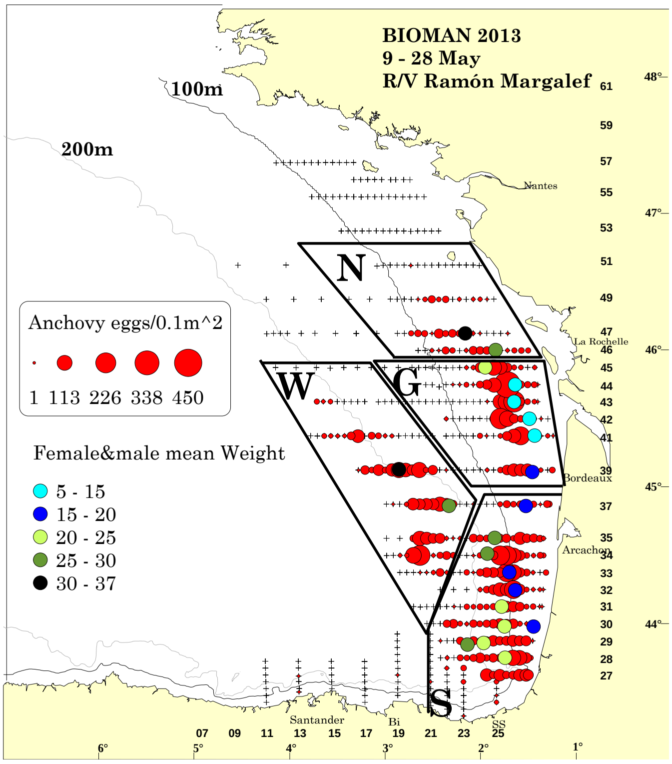

Figure 3: 4 regions defined to estimate the numbers at age. The black lines represent the border of the regions, the red bubbles de abundance of eggs in each station and the blue, green and black bubbles represent the mean size of the individuals of each haul.

Results

This year no anchovy eggs were found in the Cantabrian Coast. The spawning area started at 43º45’N in the French platform and the northern limit was found at 46º 15’N. The eggs in the French platform where encountered in the historical common places: Between Adour and Arcachon and in the area of influence of Le Gironde (**Figure 4**). The total area surveyed was 77,838 km^2 and the spawning area was 35,448 km^2. Total number of PairoVET samples obtained was 551. From those, 284 had anchovy eggs (52%) with an average of 16 eggs 0.1m^{-2} per station and a maximum of 569 eggs 0.1m^{-2} in a station. A total of 8,830 anchovy eggs were encountered and classified. The number of CUFES samples obtained was 1,222 with 63,481 anchovy eggs in total (1,221eggm^{-3}) with a mean of 10eggm^{-3}. The abundance of sardine was scarce in relation with the historical series, all the eggs where inside the 100m depth in the French platform all along the coast, no eggs were encountered in the cantabrian region (**Fig. 5**). In PairoVET a total of 213 (43%) stations had sardine eggs with an average of 8 eggs per 0.1 m^{-2} per station and a maximum of 301 eggs 0.1m^{-2}.

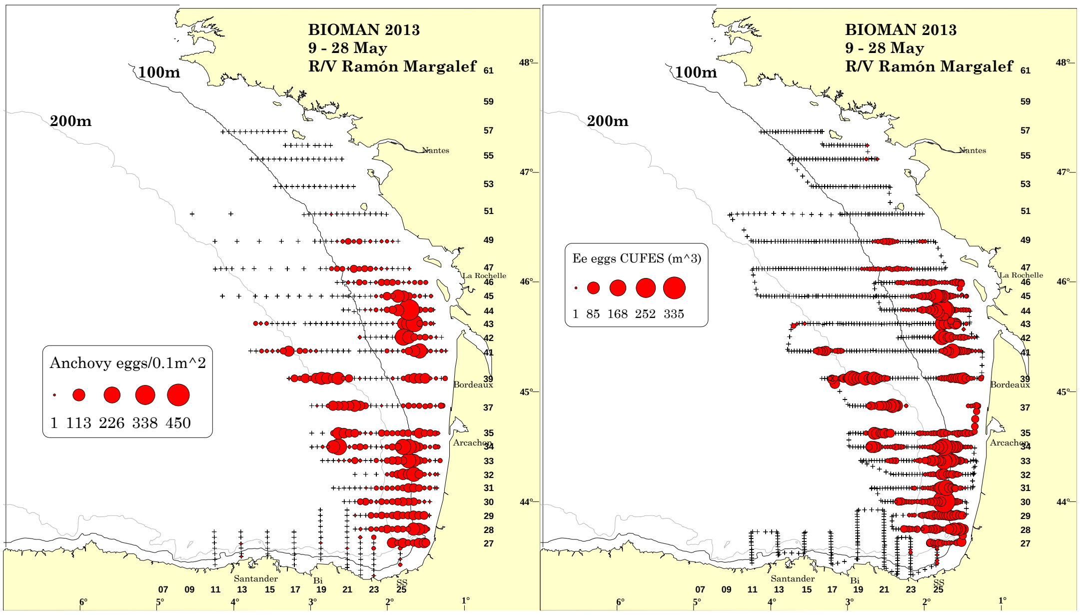

Figure 4: Distribution of anchovy egg abundances obtained with PairoVET (left) (eggs per 0.1m^2) and CUFES (right) (Egg per m^3) from the DEPM survey BIOMAN2013.

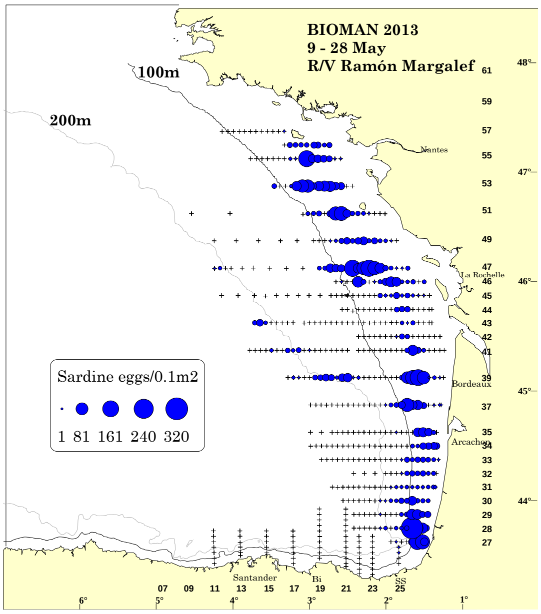

Figure 5: Distribution sardine egg abundances (eggs per 0.1m^2) from the DEPM survey BIOMAN2013 obtained with PairoVET.

Figure 6 shows the sea surface temperature and sea surface salinity maps overlapped with the abundance of anchovy eggs as observed during the BIOMAN2013 survey.

This year the mean SST of the survey (14.3ºC) was at levels of last year. The mean SSS (34.72 UPS) was at levels of last year (35.25 UPS). 2013 and 2012 have been cooler than 2011. In general his year 2013 had winter conditions.

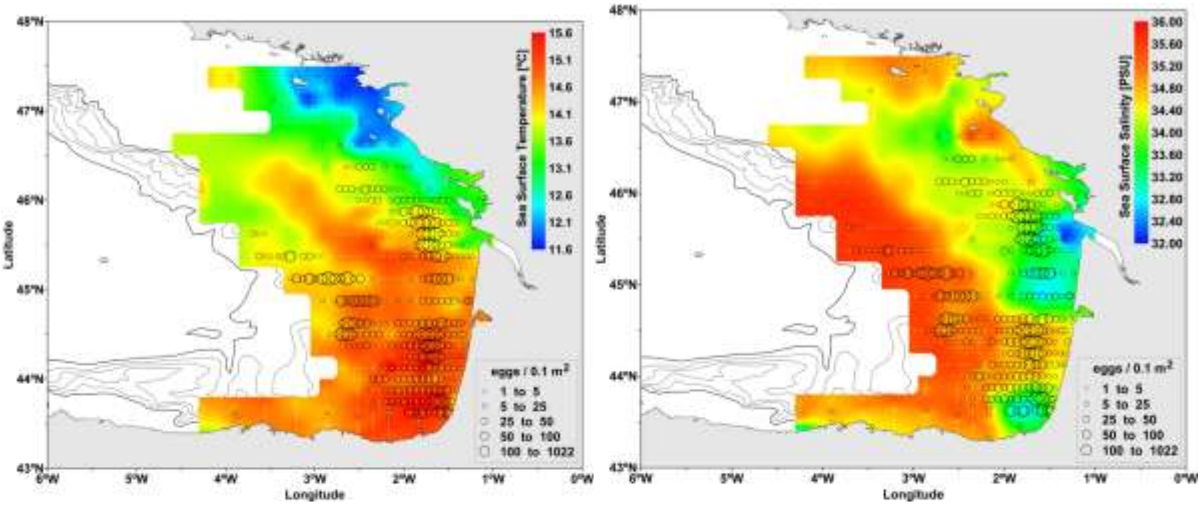

Figure 6: SST and SSS maps (left and right respectively) with anchovy egg distribution 2013.

The adult samples covered adequately the positive spawning area as shown in **Figure 3.** Overall 30 pelagic trawls were performed of these, 22 provide anchovy and 21 were selected for the analysis because the other two had a small amount of anchovy. The spatial distribution of the samples and their species composition is shown in **Figure 10.** Most hauls consisted of anchovy, horse mackerel, sardine and some mackerel. Anchovy was found in the same places where the anchovy eggs were found. Horse mackerel was found from Cap Breton to Gironde following the area between 100m and 200m depth line, some sardine near the coast between Adour and Arcachon and before and after the Gironde area and some mackerel.

Spatial distribution of mean weight (males and females) is shown in **Figure 11**. Less weight individuals were found all along the coast inside the 100 m depth isoline and in the influence of the Gironde estuary while heavier anchovies were found offshore, once passed the isoline of 100m depth.

Total daily egg production estimates

As a result of the adjusted GLM (**Fig. 7**) the daily egg production (P_0) was 91.51 egg m^{-2} day^{-1} with a standard error of 13.97 and a CV of 0.15. The daily mortality z was 0.21 with a standard error of 0.07 and a CV of 0.34. Then, the total daily egg production as the product of spawning area and daily egg production was 3.24 E+12 with a standard error of 4.95 E+11 and a CV of 0.15.

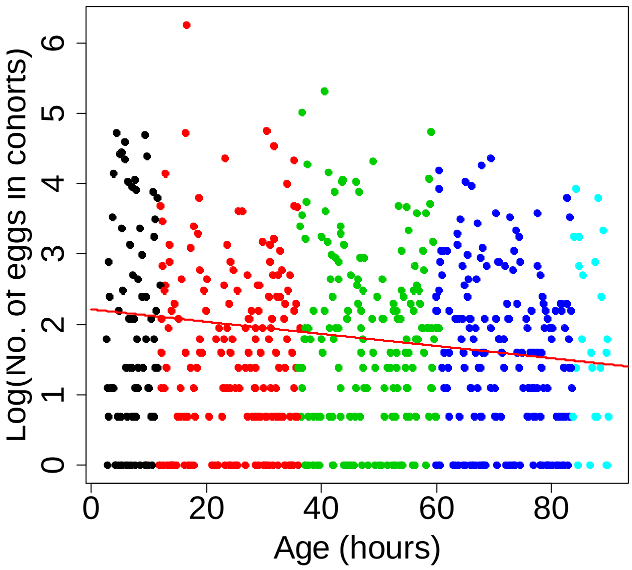

Figure 7: Exponential mortality model adjusted applying a GLM to the data obtained in the ageing following the Bayesian method (spawning peak 23:00h).The red line is the adjusted line. Data in Log scale.

Daily fecundity

The linear regression model between gonad-free-weight and total weight fitted to non-hydrated females (hydrated females identified a visu following the mature scale adopted at ICES workshop WKSPMAT) is given in **Table 1**. The extra females taken not in random, for batch fecundity, were not considered. The model fitted the data adequately (**Figure 8**, R^2=99.7%, n= 481).

The **female mean weight** was obtained as the weighted mean of the average female weights per sample (Lasker, 1985).

Table 1: Coefficients resulted from the linear regression model between gonad-free-weight and total weight fitted to non-hydrated females with their standard error and the P-Value.

Parameter	Estimate	Standard error	P-Value
Intercept	-0.4309	0.574	0
Slope	1.1071	0.0027	0

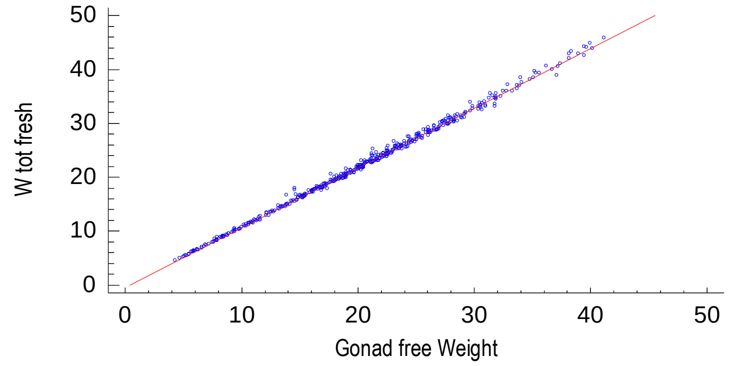

Figure 8: linear regression model between gonad-free-weight and total weight fitted to non-hydrated females.

For the **batch fecundity** 104 females were classify as hydrated a visu, from which 94 were retained after discarded the ones that presumably have POFs. Those were ranging from 7 to 38 g gonad free weight. The coefficients of the generalised linear model with Gamma distribution and identity link are given in **Table 2** and the fitted model is shown in **Figure 9**. It was tested whether the model coefficients changed between the 4 strata North, Garonne, South and West (**Figure 2**). No statistically significant differences among the regions at the 95% confidence level were found, so the model fitted to the single region was then used to estimate batch fecundity from the gonad free weight for all the females of all samples. Hence, the overall batch fecundity estimate was obtained as a weighted sample mean of the batch fecundity per sample (Lasker, 1985). The batch fecundity estimate is F= 8, 217 eggs/batch per average mature female.

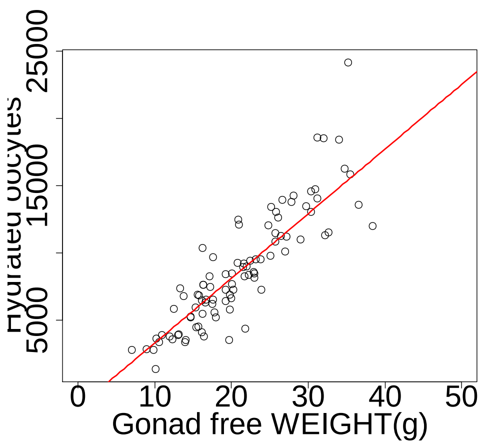

Figure 9: Generalised linear model between Weight gonad-free- and hydrated oocyted fitted to hydrated females.

Table 2: Coefficients of the generalised linear models with Gamma distribution and identity link between the number of hydrated oocytes and the female gonad free weight (Wgf).

Parameter	estimate	Standard error	Pr(>|t|)
Intercept	-1521	407	0.000316
wgf	481	25	<2e-16

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

For the **Spawning frequency** the estimate was calculated as describe above in material and methods. Estimates of the female mean weight, total mean weight, and batch fecundity, sex ratio, spawning frequency, daily fecundity and SSB with their CVs are given in **table 3 a & b**. In table 3a is showed the index of biomass with the average of the old historical series of S (0.25) and in table 3b showed the index of biomass with the average of the new historical series of S (0.40).

Table 3: All the parameters to estimate de Spawning Stock Biomass (SSB) using the Daily Egg Production Method (DEPM) for 2013: P_{tot} (total egg production), R (sex ratio), S(Spawning frequency), F (batch fecundity), W_f (female mean weight), DF (daily fecundity) and Wt (total mean weight(female and male) with correspondent Standard errors (S.e.) and coefficients of variation (CV). a) Index of biomass with the average of the traditional historical series of S (0.25). b) Index of biomass with the average of the new historical series of S (0.40)

a)

Parameter	estimate	S.e.	CV
Ptot	3.24E+12	4.95E+11	0.1526
R'	0.53	0.0044	0.0083
S	0.25	0.0087	0.0353
F	8,217	794	0.0967
Wf	21.87	1.76	0.0805
DF	49.22	2.31	0.0469
BIOMASS	**65,909**	10,523	0.1597
Wt	16.81	2.69	0.1597

b)

Parameter	estimate	S.e.	CV
Ptot	3.24E+12	4.95E+11	0.1526
R'	0.53	0.0044	0.0083
S	0.40	0.0141	0.0353
F	8,217	794	0.0967
Wf	21.87	1.76	0.0805
DF	79.51	3.73	0.0469
BIOMASS	**40,797**	6,514	0.1597
Wt	16.81	2.69	0.1597

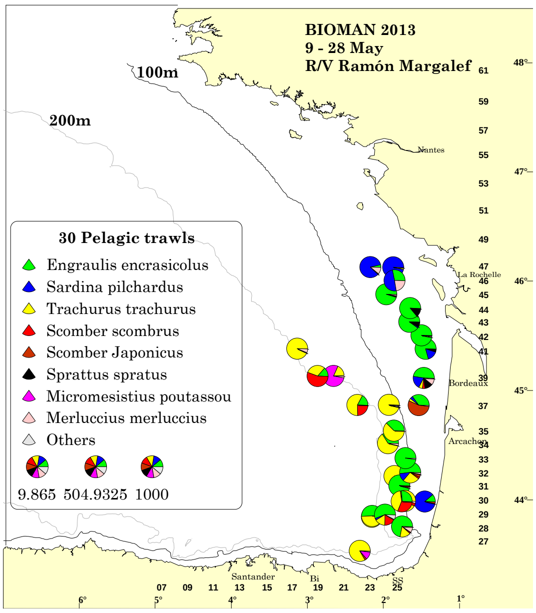

Figure 10: Species composition of the 30 pelagic trawls from the R/V Emma Bardán during BIOMAN13

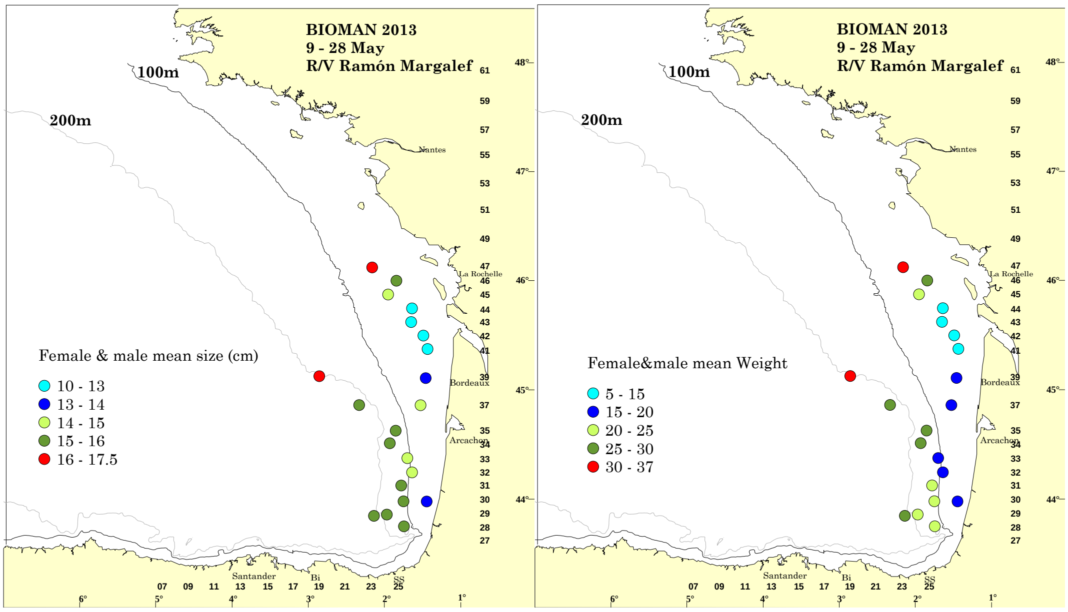

Figure 11: Anchovy (male and female) mean size (left) and weight (right) per haul 2013

SSB and Numbers at age

Until the new stock annex is accepted the index of biomass estimated with the average of the old historical series of Spawning fraction is adopted. 65,909t with a CV of 16% (**Table 3**).

For the purposes of producing population at age estimates, the age readings based on 1,676 otoliths from 21 samples were available. Estimates of anchovy mean weights and proportions at age in the population were the average of proportions at age in the samples, weighted by the population each sample represents.

Given that mean weights of anchovies change between different regions (**Figure 3**) proportionality between the amount of samples and approximate biomass, indices by regions was checked. The approximate index of biomass by regions was set equal to egg abundance divided by the daily fecundity assigned to each region (**Table 4**). According to that table, the 21 samples selected cannot be considered to be balanced between these regions and differential weighting factors were applied to each sample coming from one or the other region for the purposes of the number at age estimates and biomass estimates. The proportion by age, numbers by age, weight at age and biomass by age estimates old and new are given in **Table 5, Figure 12**. 59% of the population in numbers and 43% in mass correspond to age 1. **Figure 12** shows the distribution of anchovy age composition in space.

Table 4: Balance of the adult sampling to egg abundance by 4 regions (North-N, Gironde-G, South-S and West-W) in the Bay of Biscay (see **Figure 3**). The 6th row of the table corresponds to the weighting factor of each of the samples by region to obtain the population structure. Mean weight by regions arise from the 21 adult samples selected for the analysis.

Estrata	N	G	S	W	**Addition**
Total egg abundance	3.1E+11	2.8E+12	2.9E+12	2.4E+12	8.44.E+12
% egg abundance	4%	33%	35%	29%	100%
Nº of adult samples	2	6	11	2	21
%Egg/sample	0.02	0.05	0.03	0.14	
Proportion of SSB relative to W str.	0.13	0.38	0.22	1.00	
W. factor proportional to the population	0.13/wi	0.38/wi	0.22/wi	1/wi	
Mean weight of anchovies by region	29.73	11.86	21.44	30.04	
Standard Deviation	4.41	5.42	3.37	6.41	
CV	15%	46%	16%	21%	

Table 5: 2013 SSB (Spawning Stock Biomass) estimates and correspondent standard error (S.e.) and coefficient of variation (CV) of the percentage, numbers, weight and Spawning Stock Biomass (SSB) at age estimates.

a)

Parameter	**estimate**	**S.e.**	**CV**
Biomass (Tons)	**65,909**	10,523	0.1597
Tot. Mean W (g)	16.81	2.69	0.1597
Population (millions)	4,029	945	0.2345
Percent. age 1	0.59	0.09	0.1539
Percent. age 2	0.32	0.06	0.1988
Percent. age 3	0.08	0.03	0.3745
Numbers at age 1	2,447	884	0.3614
Numbers at age 2	1,262	220	0.1742
Numbers at age 3	320	88	0.2760
Weight at age 1 (g)	11.7		
Weight at age 2 (g)	22.8		
Weight at age 3 (g)	30.0		
SSB at age 1 (Tons)	28,144		
SSB at age 2 (Tons)	28,308		
SSB at age 3 (Tons)	9,458		
Percet. at age 1 in mass	42.7		
Percent. at age 2 in mass	42.9		
Percent. at age 3in mass	14.3		

b)

Parameter	**estimate**	**S.e.**	**CV**
Biomass (Tons)	**40,797**	6,514	0.1597
Tot. Mean W (g)	16.81	2.69	0.1597
Population (millions)	2,494	585	0.2345
Percent. age 1	0.59	0.09	0.1539
Percent. age 2	0.32	0.06	0.1988
Percent. age 3	0.08	0.03	0.3745
Numbers at age 1	1,515	547	0.3614
Numbers at age 2	781	136	0.1742
Numbers at age 3	198	55	0.2760
Weight at age 1 (g)	11.7		
Weight at age 2 (g)	22.8		
Weight at age 3 (g)	30.0		
SSB at age 1 (Tons)	17,421		
SSB at age 2 (Tons)	17,522		
SSB at age 3 (Tons)	5,854		
Percet. at age 1 in mass	42.7		
Percent. at age 2 in mass	42.9		
Percent. at age 3in mass	14.3		

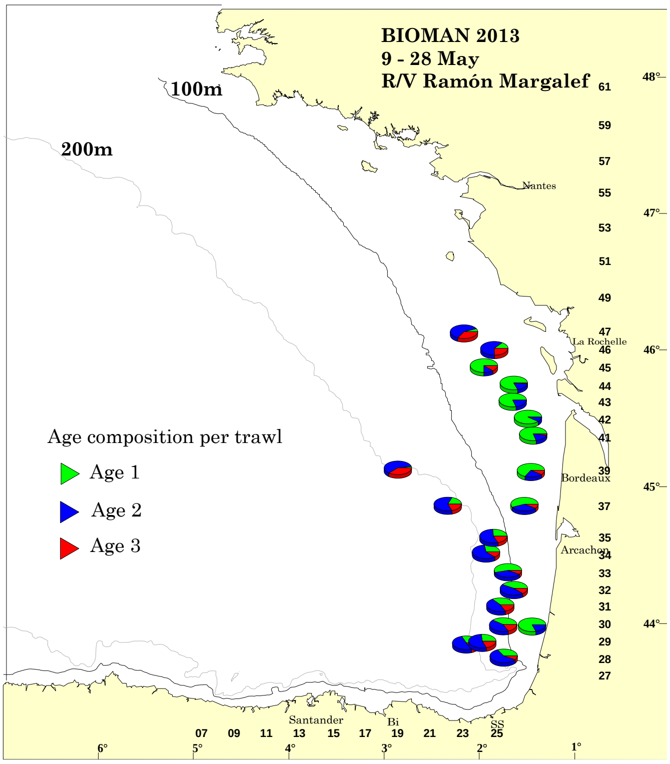

Figure 12: Anchovy age composition per haul

Historical perspective

The whole series of biomass index estimated with the DEPM, including the current preliminary estimate for 2013, are presented in **figure 13**. The historical series of numbers at age in numbers is shown in **figure 14.** In order to provide a broader point of view for the interpretation of current survey results, distribution maps of the anchovy egg abundances in the last 20 DEPM surveys were compiled (**Fig 16**).

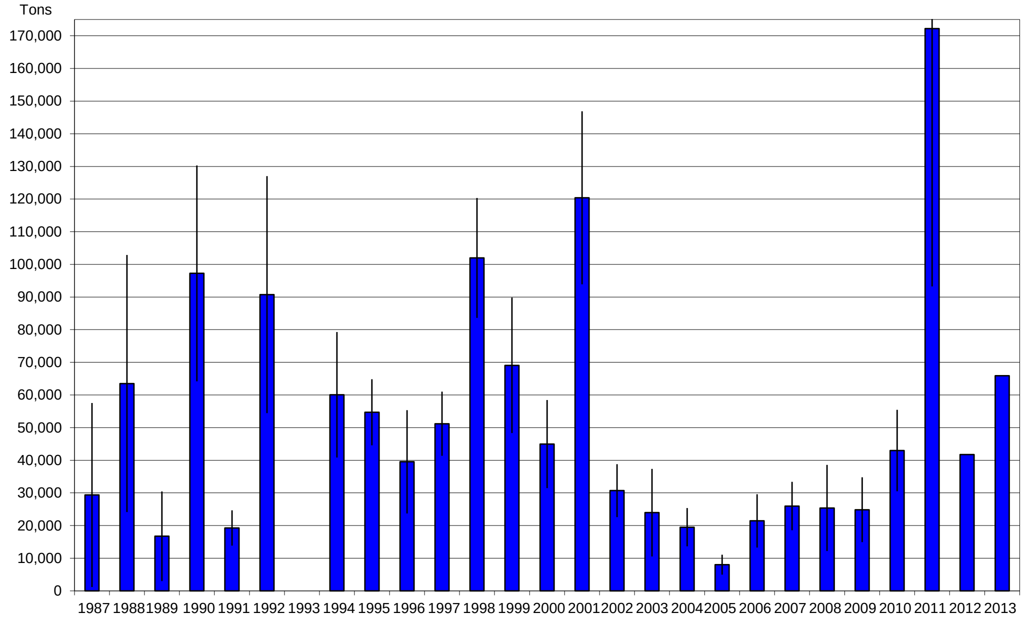

Figure 13: Series of Biomass estimates (tonnes) obtained from the DEPM since 1987. In 1996, 1999, 2000, 2007- 2013 S was deduced indirectly.

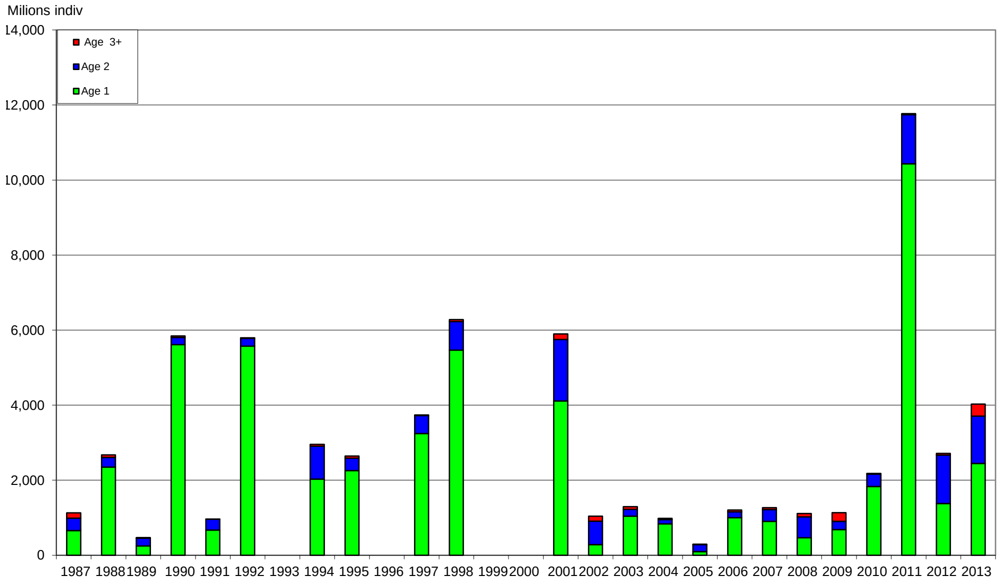

Figure 14: Historical series of numbers at age from 1987 to 2013. This year 59% of the biomass in numbers was year two.

Sardine total egg abundance

Total egg abundance for sardine was estimate as the sum of the numbers of eggs in each station multiply by the area each station represent. This year estimate is 5.5E+12 eggs, at same levels as last year. The historical series of egg abundances is shown in **figure 15**. The sardine egg distribution is shown in **figure 5** and the historical series of egg abundances distribution in **figure 17**.

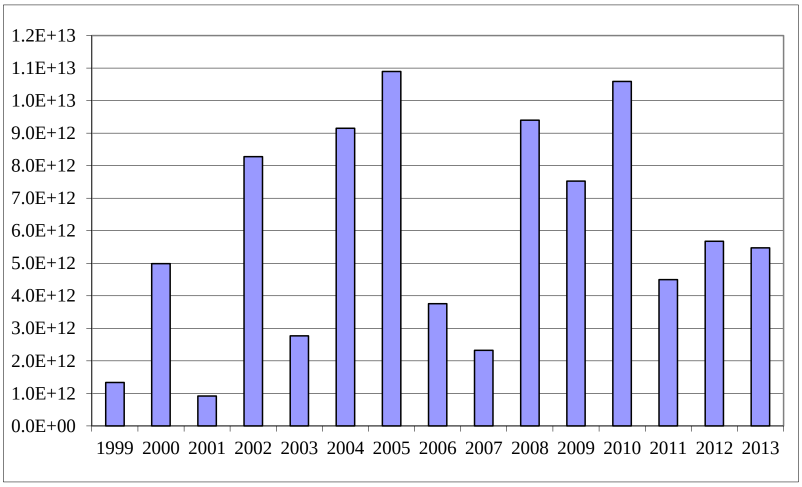

Figure 15: historical series of sardine egg abundances

Conclusions

The survey BIOMAN2013 has covered the spawning area satisfactory and the total egg production has been estimated in the distribution area of the population. Moreover there were obtained 30 pelagic trawls, from those 22 were positive for anchovy and 21 were selected for the analysis. Those were obtained simultaneously to the egg sampling.

To estimate the total egg production an exponential mortality model was applied. The adjustment of the model was satisfactory. To estimate the Daily Fecundity a mean of the old and new DF historical series was applied (0.247y6, 0.40 respectively). This procedure of applying the historical mean for DF was accorded during ICES WGACEGG 2009. Preliminary batch fecundity was estimated selecting the hydrated females a visu. Until the new stock annex is accepted the index of biomass estimated with the average of the old historical series of Spawning fraction is adopted: 65,909t with a CV of 16%.

Approximately 59% of the anchovy in numbers are individuals of age 1 and the contribution in mass of those is 43% while the anchovies of age 2 in numbers is 32% and its contribution in mass 43%. This is due to the difference in the mean weights by age.

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We thank all the crew of the R/V Ramón Margalef and Emma Bardán and all the personal that participated in BIOMAN 2013 for their excellent job and collaborative support. This work has been founded by the Agriculture, Fisheries and Food Technology Department of the Basque Government and by the European Commission within the frame of the National Sampling Programme. The General Secretariat of Sea also collaborated providing the R/V Emma Bardán.

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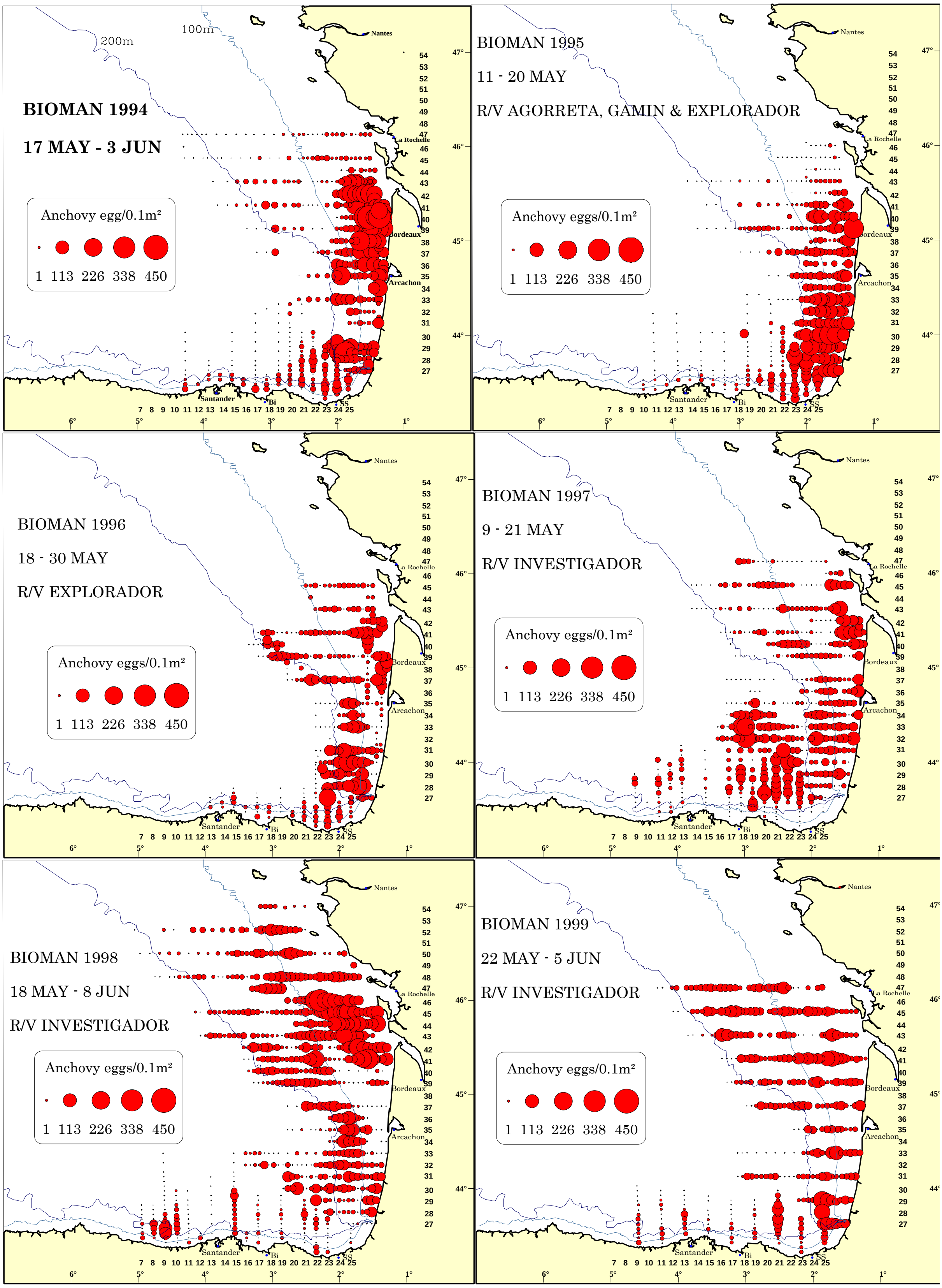
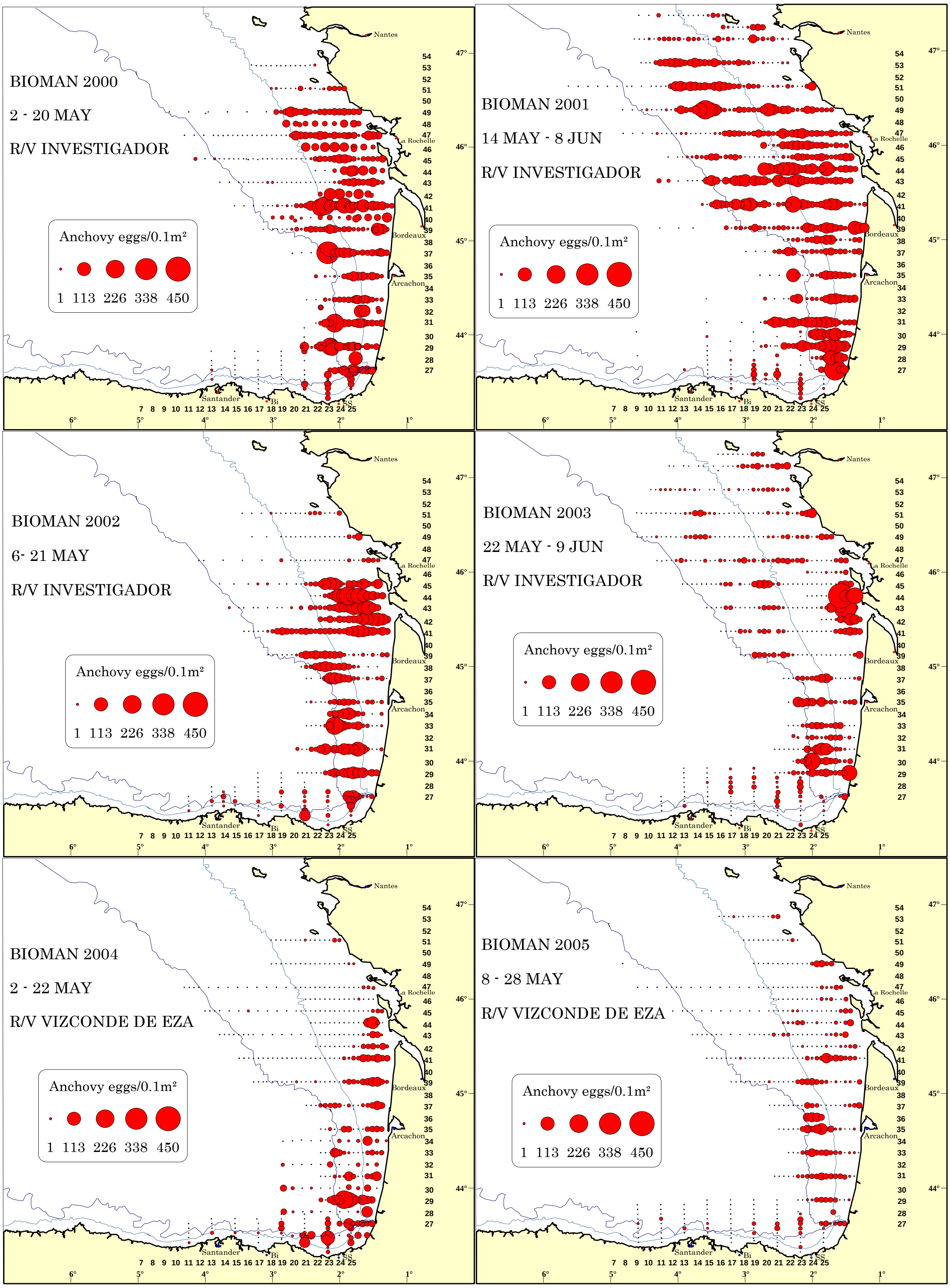


200m
100m
BIOMAN 1994
17 MAY - 3 JUN
Anchovy egg/0.1m²
1 113 226 338 450
BIOMAN 1995
11 - 20 MAY
R/V AGORRETA, GAMIN & EXPLORADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 1996
18 - 30 MAY
R/V EXPLORADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 1997
9 - 21 MAY
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 1998
18 MAY - 8 JUN
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 1999
22 MAY - 5 JUN
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
Nantes
La Rochelle
Bordeaux
Arcachon
Santander
Bi
SS
47°
46°
45°
44°
6°
5°
4°
3°
2°
1°


BIOMAN 2000
2 - 20 MAY
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2001
14 MAY - 8 JUN
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2002
6- 21 MAY
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2003
22 MAY - 9 JUN
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2004
2 - 22 MAY
R/V VIZCONDE DE EZA
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2005
8 - 28 MAY
R/V VIZCONDE DE EZA
Anchovy eggs/0.1m²
1 113 226 338 450
Nantes
La Rochelle
Bordeaux
Arcachon
Santander
47°
46°
45°
44°
6°
5°
4°
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2°
1°

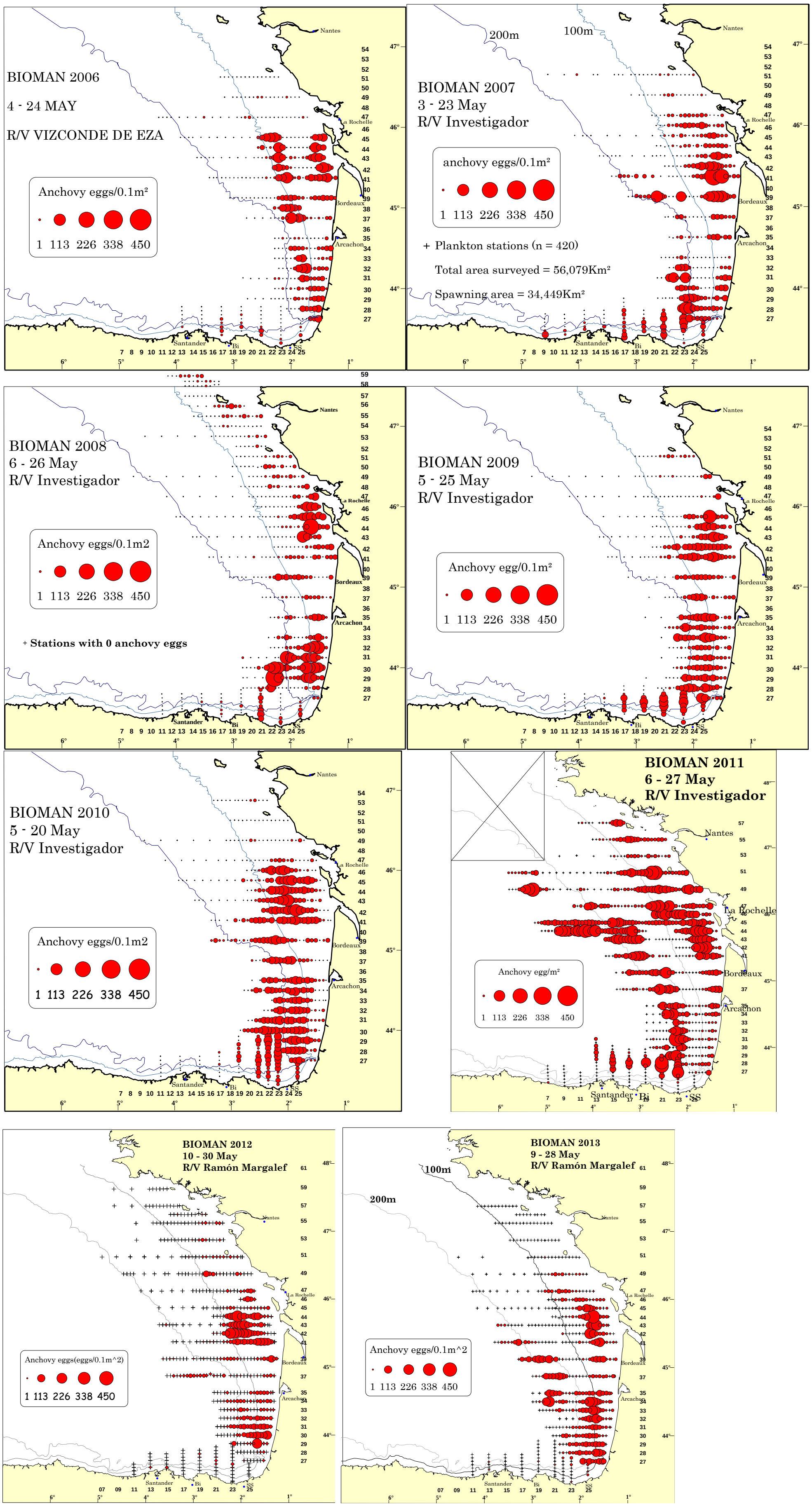
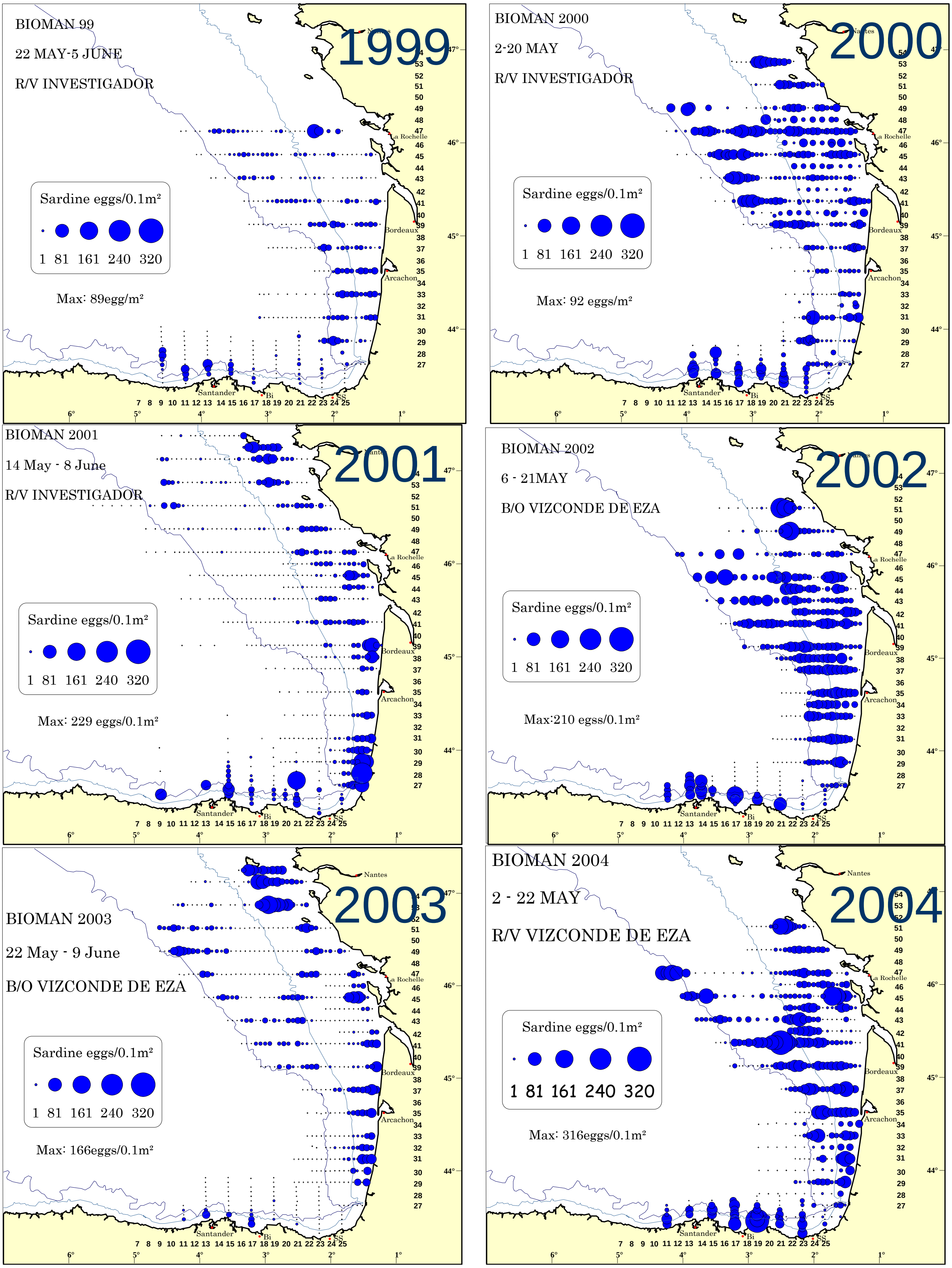
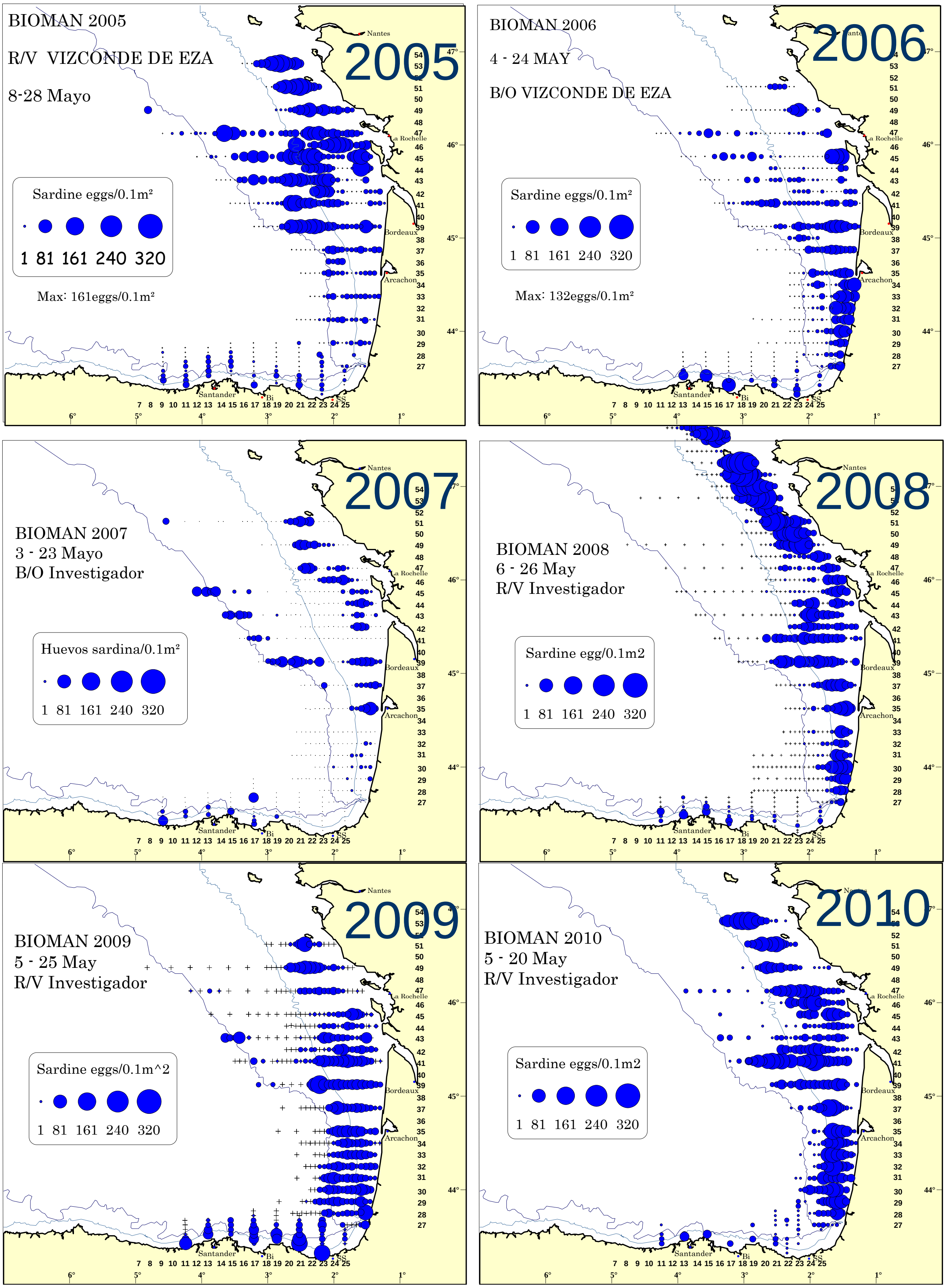


Figure 16: Anchovy egg distribution and abundance from 1994 to 2013.


BIOMAN 99
22 MAY-5 JUNE
R/V INVESTIGADOR
1999
Sardine eggs/0.1m²
1 81 161 240 320
Max: 89egg/m²
BIOMAN 2000
2-20 MAY
R/V INVESTIGADOR
2000
Sardine eggs/0.1m²
1 81 161 240 320
Max: 92 eggs/m²
BIOMAN 2001
14 May - 8 June
R/V INVESTIGADOR
2001
Sardine eggs/0.1m²
1 81 161 240 320
Max: 229 eggs/0.1m²
BIOMAN 2002
6 - 21MAY
B/O VIZCONDE DE EZA
2002
Sardine eggs/0.1m²
1 81 161 240 320
Max:210 egss/0.1m²
BIOMAN 2003
22 May - 9 June
B/O VIZCONDE DE EZA
2003
Sardine eggs/0.1m²
1 81 161 240 320
Max: 166eggs/0.1m²
BIOMAN 2004
2 - 22 MAY
R/V VIZCONDE DE EZA
2004
Sardine eggs/0.1m²
1 81 161 240 320
Max: 316eggs/0.1m²
Nantes
La Rochelle
Bordeaux
Arcachon
Santander
Bi
SS
47°
46°
45°
44°
6°
5°
4°
3°
2°
1°


BIOMAN 2005
R/V VIZCONDE DE EZA
8-28 Mayo
2005
Sardine eggs/0.1m²
1 81 161 240 320
Max: 161eggs/0.1m²
BIOMAN 2006
4 - 24 MAY
B/O VIZCONDE DE EZA
2006
Sardine eggs/0.1m²
1 81 161 240 320
Max: 132eggs/0.1m²
BIOMAN 2007
3 - 23 Mayo
B/O Investigador
2007
Huevos sardina/0.1m²
1 81 161 240 320
BIOMAN 2008
6 - 26 May
R/V Investigador
2008
Sardine egg/0.1m2
1 81 161 240 320
BIOMAN 2009
5 - 25 May
R/V Investigador
2009
Sardine eggs/0.1m^2
1 81 161 240 320
BIOMAN 2010
5 - 20 May
R/V Investigador
2010
Sardine eggs/0.1m2
1 81 161 240 320
Nantes
La Rochelle
Bordeaux
Arcachon
Santander
Bi
SS
47°
46°
45°
44°
6° 5° 4° 3° 2° 1°
7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

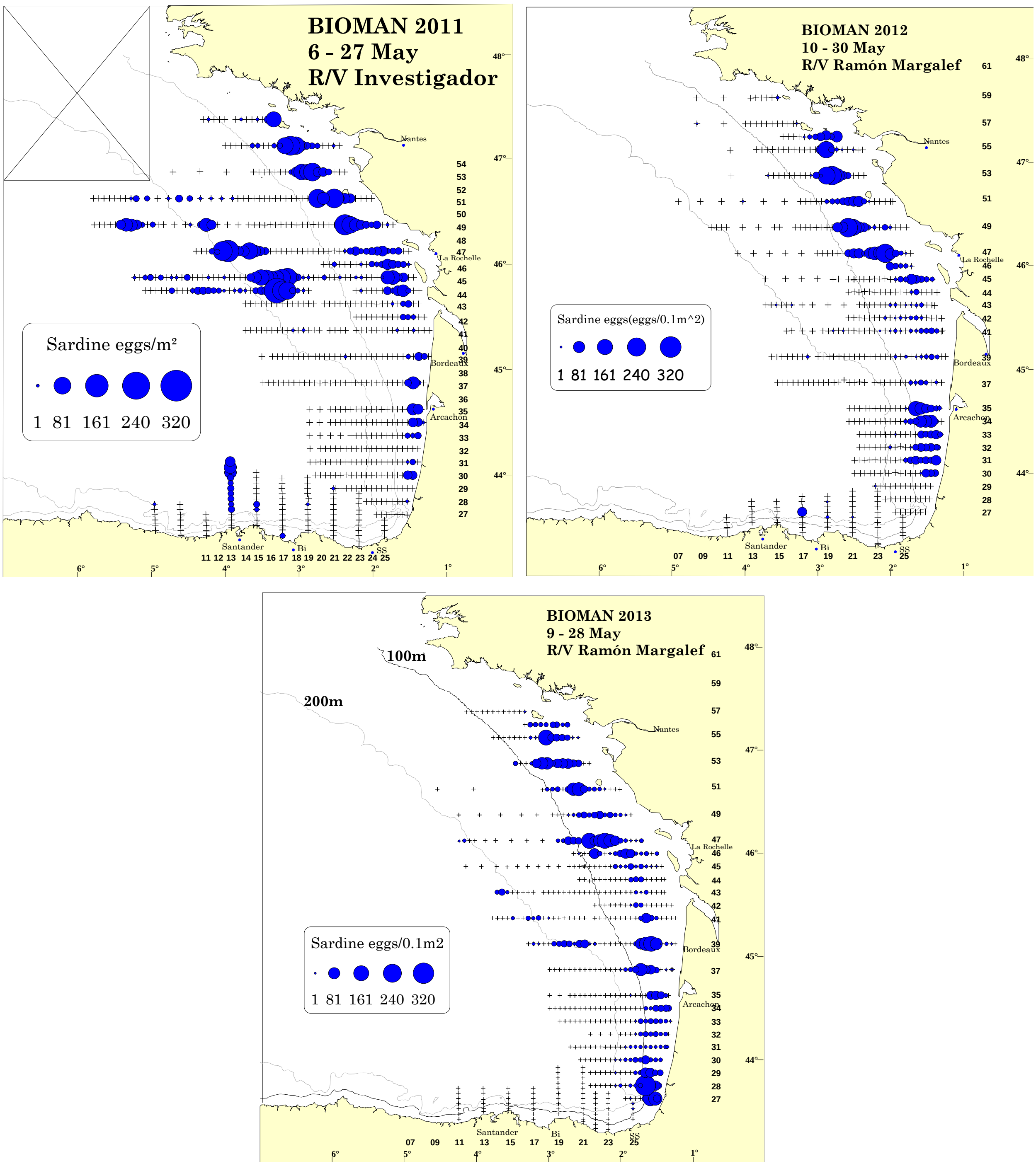


Figure 17: Sardine egg distribution and abundance from 1999 to 2013.

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PRELIMINAR RESULTS OF THE PELACUS0313 SURVEY: ESTIMATES OF SARDINE ABUNDANCE AND BIOMASS IN GALICIA AND CANTABRIAN WATERS

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Abstract

The PELACUS 0313 survey was undertook this year on board R/V Miguel Oliver, an oceanographic stern trawler ship similar to Thalassa. The survey was characterised by a very bad weather conditions during the first two weeks which did not allow working properly. Moreover, the weather conditions during the rest of survey were almost similar. As a consequence, most of the coastal pelagic fish community remained very close to the coast, thus not accessible to the pelagic gear samplers. (33% of the total acoustic energy –NASC- was unable to be properly allocated into fish species).

Outside the coastal area (>90 m depth) sardine distribution was scarce, and occurred in small schools (probably as a consequence of the bad weather condition). It was only found in a small area in VIIIc-West and in the eastern part of the VIIIc-East. The total biomass estimated in this area was 2.530 tonnes corresponding to 38,4 million fish.

Together with this assessment, made on account the fish proportion found at the ground truth fishing station, a direct assignation was achieved by echogram scrutinization. Although the experience, only few schools could be properly allocated to sardine, all of them located inside the Rias Baixas, giving an estimation of 813 tonnes (16 million fish). Overall, total biomass estimation is 3.343 tonnes, corresponding to 54 million fish.

On the contrary, the number of sardine eggs found at the CUFES stations showed an increase compared to those found in 2012 (from 1665 to 5936). Nevertheless, the distribution area was rather similar, with a significant gap between the southern area (IXaN) and the inner part of the Bay of Biscay (VIIIc-East-east).

Given the amount of unallocated schools in shallower waters, the acoustic sardine assessment is considered unreliable since only the inner part of the distribution (waters deeper than 90 m) was properly surveyed. The egg distribution, similar to that found the last year could indicate that the stock estimation would be similar. On the other hand, the significant increase in egg number would be either related with the shift in the survey time (two weeks earlier than the

previous year), thus arriving at the peak spawning, or with an increase in the sardine abundance.

Introduction

PELACUS 0313 is the latest of the long-time series (started in 1984) of spring acoustic surveys carried out by the Instituto Español de Oceanografía to monitor pelagic fishery resources in the north and northwest shelf of the Iberian Peninsula (ICES divisions IXa – South Galicia and VIIIc – Cantabrian Sea).

This year the survey was carried out on board R/V Miguel Oliver. This ship, made in 2007, is similar to the Thalassa, vessel traditionally used for the survey since 1997 (i.e. a 70 m length stern trawler with diesel-electric power and fixed pitch propeller, within the standard ship underwater radiated noise recommended in ICES CRR 209). Before the cruise, the ship was tested, including acoustic calibration (Foote *et al.*, 1987), during a small survey performed in February in Galician waters.

We present the results on the distribution of sardine egg and adult fish together with the estimated values of adult fish abundance and biomass obtained in the survey. We also compare the new values with those obtained in previous years.

Material and methods

The methodology was similar to that of the previous surveys (see Iglesias et al. (2010) for further details). Survey design consisted in a grid with systematic parallel transects equally separated by 8 nm and perpendicular to the coastline (Figure 1) with random start, covering the continental shelf from 30 to 1000 m depth and from Portuguese-Spanish border to the Spanish -French one. Acoustic records were obtained during day time together with egg samples from a Continuous Underwater Fish Egg Sampler (CUFES), with an internal water intake located at 5 m depth. CTD casts and plankton and water samples were taken during night time over the same grid in alternating transects. Besides, pelagic trawl hauls were performed in an opportunistic way to provide ground-truthing for acoustic data.

Acoustic equipment consisted in a Simrad EK-60 scientific echosounder (18, 38, 120 and 200 KHz). The elementary distance sampling unit (EDSU) was fixed at 1 nm. Acoustic data were obtained only during daytime at a survey speed of 10 knots. Data were stored in raw format and post-processed using SonarData Echoview software (Myriax Ltd.). The integration values are expressed as nautical area scattering coefficient (NASC) units or s_A values (m^2 nm^{-2}) (MacLennan *et al.*, 2002).

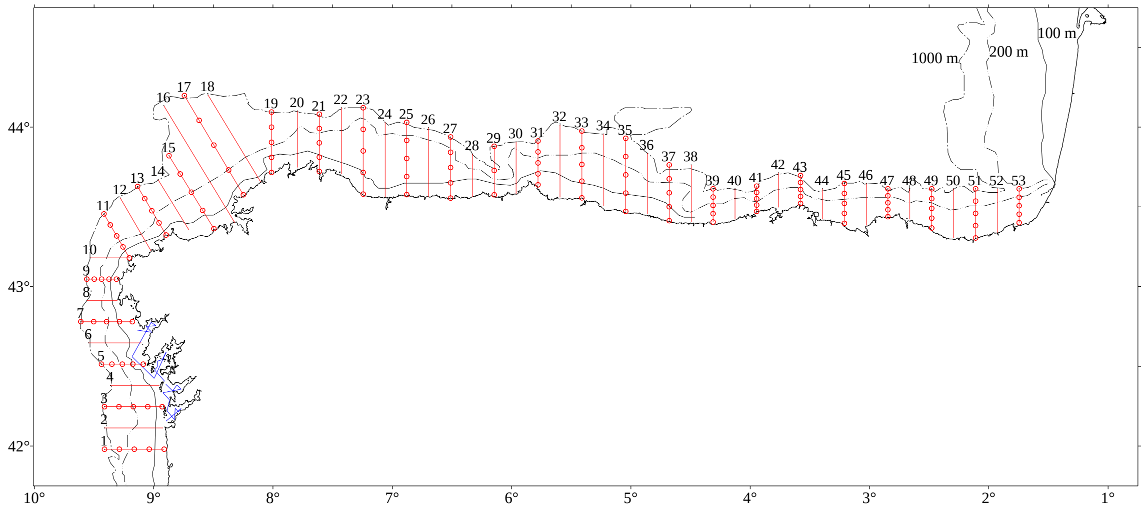

Figure 1 Survey track

Two different pelagic gears were used. Nevertheless, due to the bad weather condition and the specific characteristics of those trawls, hauls were mainly performed in depths higher than 90 m (coastal areas with hard, rough bottoms were inaccessible when fish schools occurred close to the seabed). Hauls had a minimum duration of 20 minutes. A two steps method was used to assess the pelagic fish community. First, hauls were classified on account the following criteria: weather condition, gear performance and fish behaviour in front of the trawl derived from the analysis of the net sonar (Simrad FS20/25), catch composition in number and length distribution. Each haul was categorised and ranked as follows:

	0	**1**	**2**	**3**
Gear performance Fish behaviour	Crash	Bad geometry Fish escaping	Bad geometry No escaping	God geometry No escaping
Weather conditions	Swell >4 m height Wind >30 knots	Swell: 2 -4 m Wind: 30-20 knots	Swell: 1-2m Wind 20-10 knots	Swell <1 m Wind < 10 knots
Fish number	total fish caught <100	Main species >100 Second species <25	Main species > 100 Second species< 50	Main species > 100 Second species > 50
Fish length distribution	No bell shape	Main species bell shape	Main species bell shape Seconds: almost bell shape	Main species bell shape Seconds: bell shape

These criteria were used as a proxy for ground-truthing. Hauls considered as the best representation of the fish community (i.e. those with higher overall rank on account the four criteria) were used to allocate the backscattering energy got on similar echotraces located in the same area.

Once backscattering energy was allocated, spatial distribution for each species was analysed on account both the NASC values and the length frequency distributions (LFD). These were obtained for all the fish species in the trawl (either from the total catch or from a representative random sample of 100-200 fish). For the purpose of acoustic assessment, only those size distributions which were based on a minimum of 30 individuals and which presented a bell shape (normal) distribution were considered. Random subsamples were taken when the total fish caught was higher than 100 specimens. Differences in probability density functions (PDF) were tested using Kolmogorov-Smirnoff (K-S) test. PDF distributions without significant differences were joined, giving a homogenous PDF stratum. Spatial structure and surface (square nautical miles) for each stratum were calculated using EVA and SURFER packages. Fish abundance was calculated with the 38 kHz frequency as recommended at the PGAAM (ICES 2002). Nevertheless, echograms from 18 and 120 kHz frequencies were used to visually discriminate between fish and other scatter-producing objects such as plankton or bubbles, and to distinguish different fish according to the strength of their echo. Also these frequencies have been used to create a mask allowing a better discrimination among fish species and plankton. The threshold used to scrutinize the echograms was –70 dB. Backscattered energy (s_A) was allocated to fish species according to the proportions found at the fishing stations (Nakken and Dommasnes, 1975). For this purpose, the following TS values were used: sardine and anchovy, -72.6 dB (b_{20}); horse mackerels (*Trachurus trachurus, T. picturatus* and *T. mediterraneus*), –68.7 dB, bogue (*Boops boops*), –67 dB, chub mackerel (*Scomber colias*), -68.7, mackerel (*Scomber scombrus*), –84.9 dB and blue whiting (*Micromesistius poutassou*), -67.5 dB. When possible, direct allocation was also used. Biomass estimation was done on each strata (polygon) using the arithmetic mean of the backscattering energy (NASC, s_A) attributed to each fish species and the surface expressed in square nautical miles.

Besides each fish was measured and weighed to obtain a length-weight relationship. Otoliths were also extracted from anchovy, sardine, horse mackerel, blue whiting and mackerel in order to estimate age and to obtain the age-length key (ALK) for each species for each area.

Results

A total of 3642 nautical miles were steamed, 1080 corresponding to the survey track. In IXa-N, due to the bad weather conditions, half of the transects were not surveyed and the rest, together with those located in the VIIIc-W Sub-Division, have had to be sternway steamed to avoid bubbles sweep down. This can cause attenuation of sound transmission and reception of backscattering energy, thus an underestimation of the fish population. This phenomenon still persisted and, therefore, acoustic records gathered in the western areas were filtered to remove those pings with a large amount of attenuation. For each ping of the 38 kHz frequency, Sv were tested for deviations (a total of 500 samples-Sv values- in the echogram for each ping). If the maximum value of Sv achieved in the water column was lower than -70dB, we assumed that an important attenuation occurred and therefore the ping was removed. This was applied until the 22nd March when main swell and wind directions were either stern or bow way. The number of pings removed is shown in the following table

Day	Total ping number	Pings removed	%
08/03/13	35388	783	2.21
09/03/13	64659	1175	1.82
10/03/13	22408	356	1.59
11/03/13	27790	1274	4.58
12/03/13	44615	935	2.10
13/03/13	47876	955	1.99
14/03/13	26872	123	0.46
15/03/13	32980	217	0.66
16/03/13	55257	451	0.82
17/03/13	49619	501	1.01

18/03/13	33884	1516	4.47
19/03/13	40805	505	1.24
21/03/13	93009	2140	2.30
22/03/13	61923	394	0.64

Sternway steaming has considerable reduced the number of ping removed. However, the coverage in the continental shelf was reduced by a 50%.

A total of 45 fishing station were performed, one of them was removed. Figure 2a-d shows the location and the value for each ground truthing criteria (from 0 to 3).

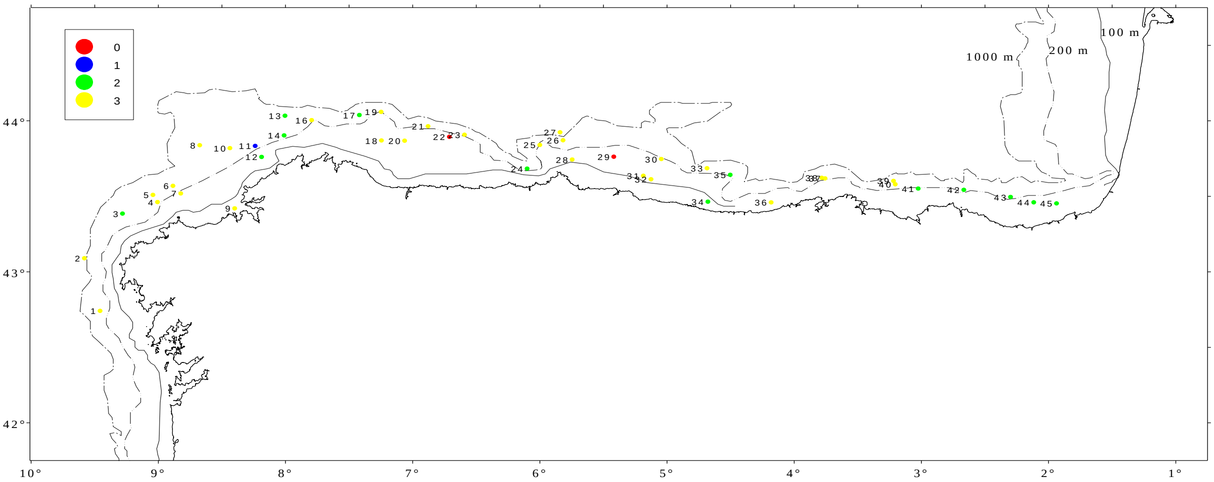

Figure 2a: Fishing station and colour system according with the Gear performance and fish behaviour criteria

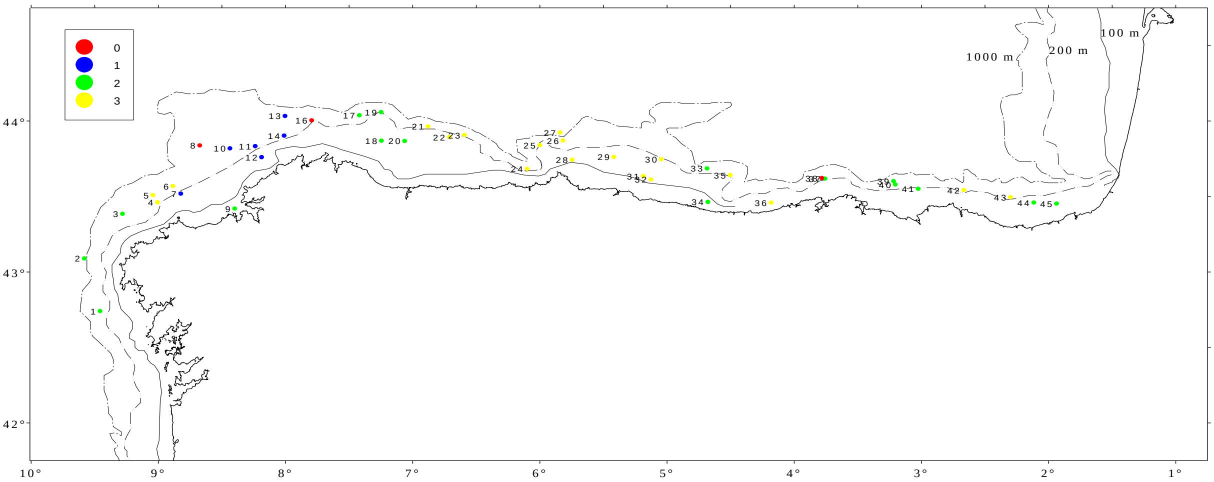

Figure 2b: Id according with the Weather condition criteria

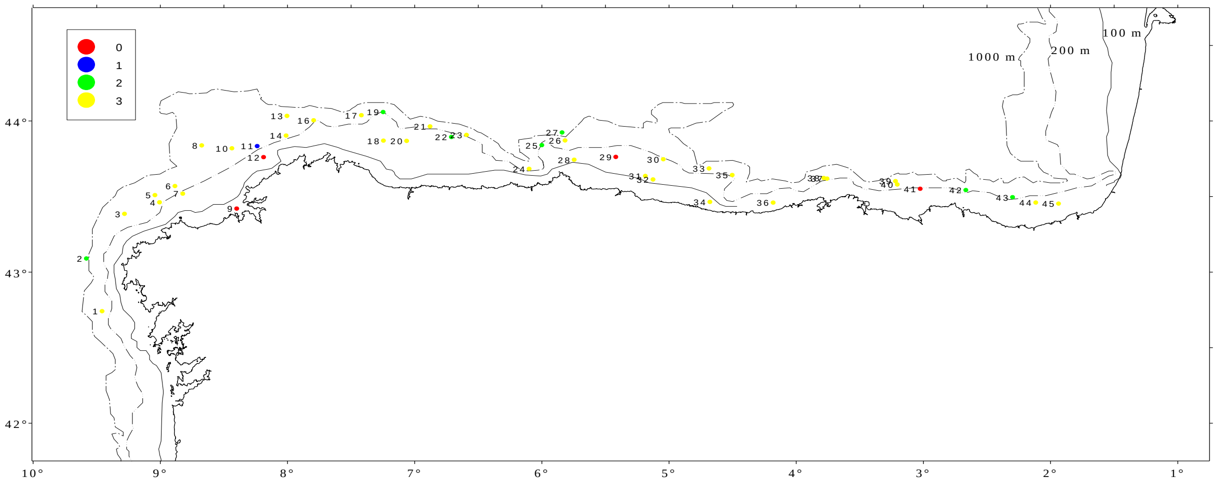

Figure 2c: Id according with the Fish number criteria

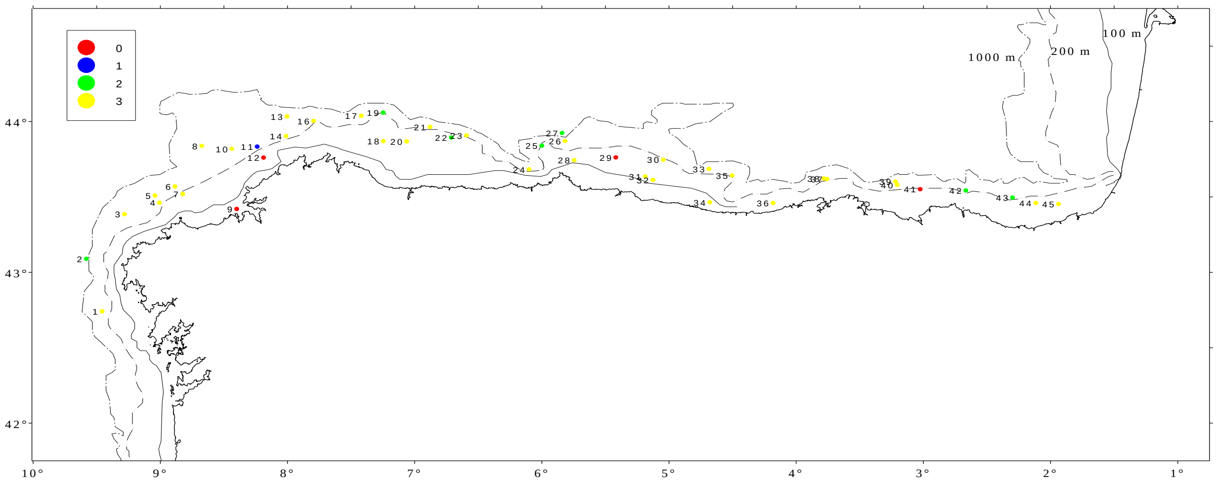

Figure 2d: Id according with the Fish length distribution criteria

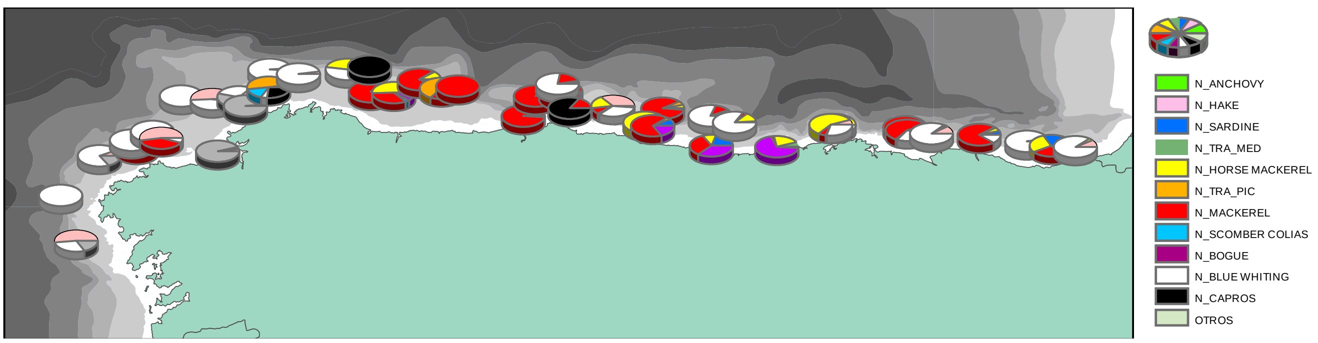

Figure 2e: Fish proportion at each fishing station

On the other hand, 381 CUFES stations, comprising 3 nautical miles each were taken, as shown in figure 3.

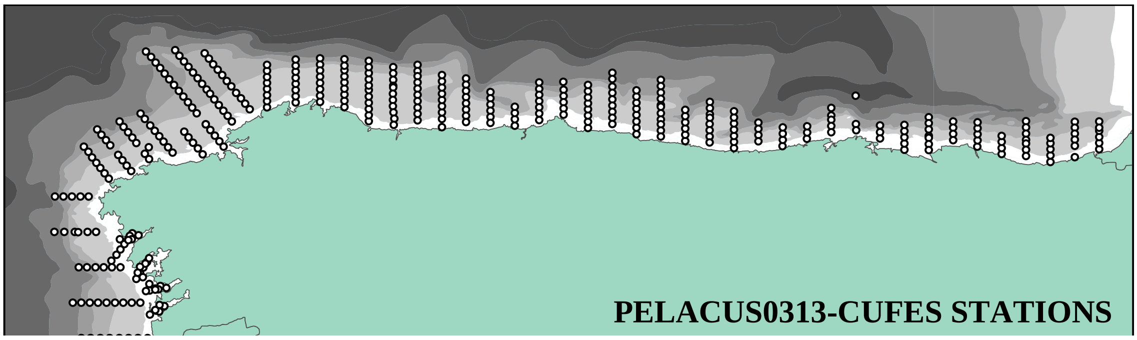

Figure 3. PELACUS0313 CUFES stations.

Results

Acoustic

A total of 105.384,67 s_A were attributed to fish species. Table 1 shows the fishing station used to allocate backscattering energy when echotraces were similar to those found around these fishing station.

Table 1: Fishing station used for backscattering energy allocation and transects

Fishing station	Transects
PE02	RA01, RA03, RA05, RA07, RA09
PE03	RA11
PE04	RA12, RA13, RA14, RA15, RA16, RA17
PE05	RA12, RA13
PE06	RA14
PE08	RA16, RA17, RA18
PE13	RA19
PE14	RA19, RA20
PE16	RA21
PE17	RA22, RA25
PE18	RA21, RA22, RA23, RA24
PE19	RA23
PE20	RA24
PE21	RA25
PE22	RA26
PE23	RA26, RA27
PE24	RA29
PE25	RA30
PE26	RA31
PE27	RA31
PE28	RA30, RA31
PE30	RA34, RA35, RA37
PE31	RA33, RA34
PE31	RA35
PE32	RA33, RA34, RA35, RA36, RA37
PE33	RA36, RA37
PE34	RA36, RA37, RA38, RA39, RA40
PE35	RA38, RA39
PE36	RA39, RA40
PE37	RA42, RA43
PE38	RA40, RA41, RA42, RA43
PE39	RA44, RA45, RA46, RA47
PE40	RA44, RA45, RA46, RA47
PE42	RA48
PE43	RA48, RA48, RA49, RA50
PE44	RA49, RA50, RA51, RA52, RA53

Due to the bad weather conditions and gear performance limitations to properly work close to the coast with hard and rough sea bed, a 33% of the total backscattering energy (34.720,97 s_A) was no possible to allocate and therefore remained as unallocated. Table 2 shows the backscattering energy distributed by species and ICES subdivision, either by direct allocation (DA) or through the proportion found at de fishing stations (Fst). Direct assignation was feasible accounting for its special acoustic properties, morphology and geographical characteristics for some sardine schools, board fish, horse mackerel and sardine. In IXa-N the 55% of the energy was unallocated (4% of the total energy); in VIIIc-W, the 37 % (5% of the total); in VIIIc-Ew, the 28% (18 % of the total energy); and in VIIIc-Ee, the 41% (6% of the total energy).

Table 2: Backscattering energy (s_A) allocated by species, both by direct allocation (DA) and by the fish proportion found at the ground-truth fishing stations, and by ICES Sub-Division

		WHB	MAC	HOM	PIL	JAA	BOG	MAS	BOC	SBR	HMM	NEI	total
IXa	**DA**			382.8	1897.3							4188.0	6468.1
	Fst	1214.3		0.7									1215.0
VIIIc-W	**DA**		28.6						737.1			5536.4	6302.1
	Fst	6768.5	1419.1	122.9	4.8	120.6		65.4	5.6	0.4			8507.4
VIIIc-Ew	**DA**		3424.1		749.0				2315.2			18975.9	25464.1
	Fst	16207.1	2631.8	8213.8	598.6	2131.4	9647.3	921.9	2182.3	64.6	29.3		42628.1
VIIIc-Ee	**DA**		577.2									6020.6	6597.9
	Fst	3270.9	579.2	3203.3	839.2	45.1	202.5	61.5	0.3				8202.0
Total	**DA**		4029.9	382.8	2646.2	0.0	0.0	0.0	3052.3			34721.0	44832.2
	Fst	27460.9	4630.0	11540.8	1442.6	2297.0	9849.8	1048.8	2188.2	65.0	29.3		60552.5
Total		27460.9	8659.9	11923.6	4088.8	2297.0	9849.8	1048.8	5240.4	65.0	29.3	34721.0	105384.7

Sardine distribution and assessment

Sardine was detected mainly in south Galicia (ICES sub-areas IXa-N), and in a very low density in VIIIc-W, and was almost absent in the central area, with only scarce detections found in the eastern part of Asturias (ICES sub-area VIIIcE-w) and in the Basque country (ICES sub-area VIIIcE-e) (Figure 5). Contrary to the normal behaviour, sardine seemed to occur in small pelagic schools, mixed with similar echotraces belonging to other species, mainly bogue, as shown in figure 4:

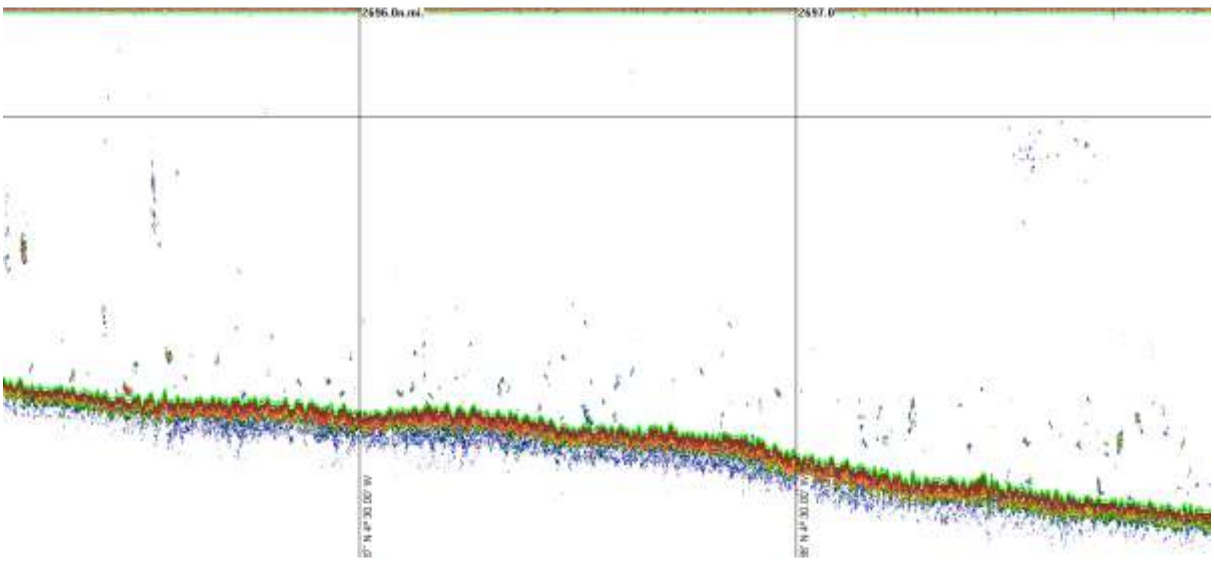

Figure 4: Sardine occurrence in Cantabrian Sea

Adult sardine were found in sufficient numbers to present a representative length distribution in only 6 of the 57 trawl hauls completed during the survey (see Figure 3). The total sardine abundance for the whole area surveyed was estimated as 54.35×10^6 individuals corresponding to 3,342.77 tons.

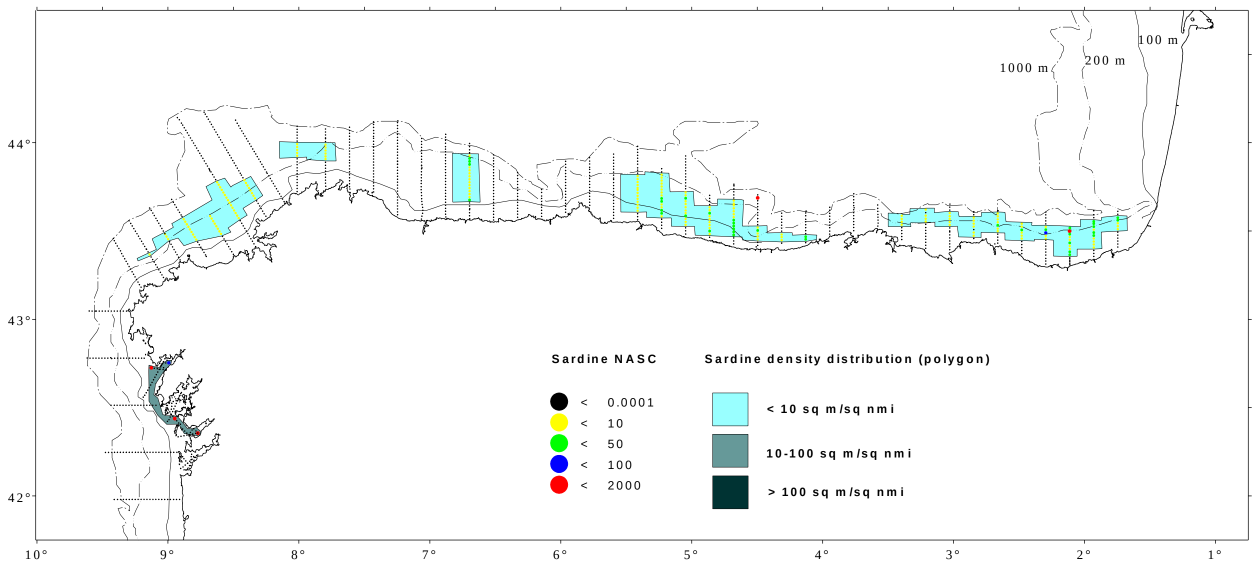

Figure 4. Sardine: spatial distribution of energy allocated to sardine during the PELACUS0313cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates integrated energy in m^2 within each polygon.

Table 3 Sardine acoustic assessment

Zone	Area	No	Mean	σ̃²	Model	v*	nugget/model	Area	Fishing st.	PDF	No (million fish)	Biomass (tonnes)
IXa	Rias Baixas	42	45.18	31014.79	5000+Sph(34000,4)	1362.358	8.7	89	M01-M02	S04	16	813
	Total	**42**	**45**					**89**			**16**	**813**
VIIIc-W	Artabro	45	0.06	0.008	na	na	Na	380	P12-P14	S01	0.07	5.71
	Estaca	11	1.62	6.83	na	na	Na	107	P12-P14	S01	0.47	40.22
	Total	***56***	***0.37***					***486***			***1***	***46***
VIIIc-Ew	Masma	16	6.40	5.33E+01	5+Sph (48, 4.5)	5.38	6%	147	P12-P14	S01	3	220
	Asturias	75	6.40	57.41	na	na	Na	589	P31-P32-P34	S02	13	820
	Total	***91***	***6.40***					***737***			***15***	***1040***
VIIIc-Ee	Euskadi	64	13.11	2275.65	na	na	Na	516	P42-P44	S03	23	1444
	Total	**64**	**13**					**516**			**23**	**1444**
	Total IXa	***42***	***45***					***89***			***16***	***813***
	Total VIIIc	***211***	***7***					***1739***			***38***	***2530***
	Total Spain	***253***	***13.20***					***1829***			***54***	***3343***

Sardine ranged in length from 14 to 24.5 cm, with a mode at 21.5 cm (Figure 5) which corresponds to quite large fish. Most fish (24% of the abundance and 19% of the biomass) in the entire surveyed area were assigned as belonging to the age class 5 (Table 4, Figure 6).
By sub-area, in subdivision IXaN (South of Galicia) the population was dominated by age 1 fish whilst in the eastern part of the Cantabrian area the population was mainly composed by older individuals (age 5). The age composition of the subdivision VIIIcW is not very reliable, since is based in few individuals.

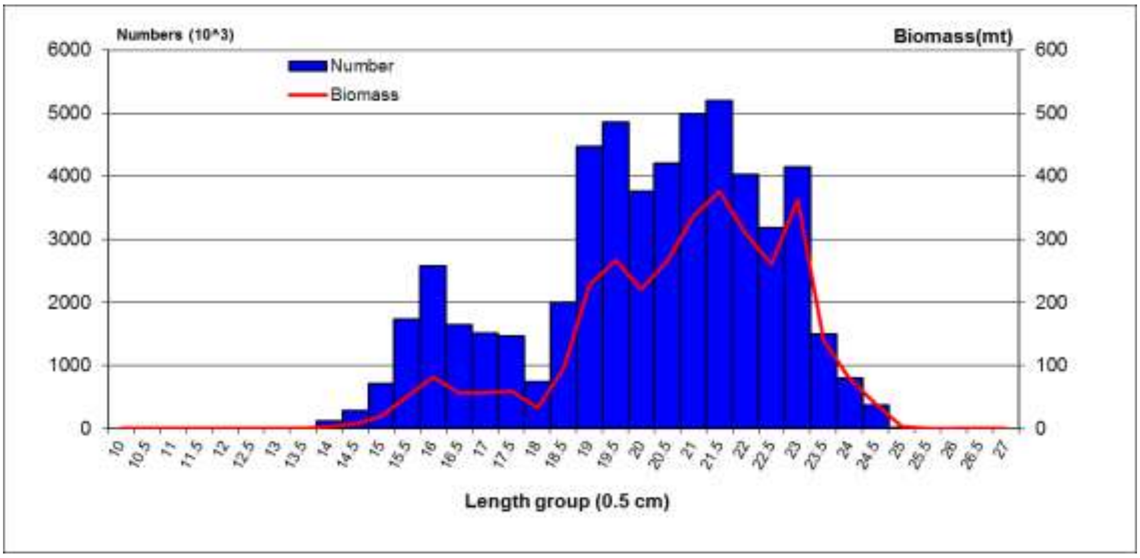

Figure 5. Sardine: fish length distribution in biomass and abundance during the PELACUS0313 survey.

Table 4. Sardine abundance in number (thousand fish) and biomass (tons) by age group and ICES sub-area in PELACUS0313.

AREA VIIIcE											
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (Tonnes)	91	498	524	359	626	283	58	37	8		2484
% Biomass	3.7	20.0	21.1	14.5	25.2	11.4	2.4	1.5	0.3		100
Abundance (N in '000)	2851	9035	8638	4846	8095	3303	661	386	74		37888
% Abundance	7.5	23.8	22.8	12.8	21.4	8.7	1.7	1.0	0.2		100
Medium Weight (gr)	31.95	55.11	60.62	74.13	77.32	85.82	88.35	94.98	104.91		74.8
Medium Length (cm)	16.28	19.73	20.41	21.92	22.23	23.09	23.32	23.94	24.80		21.7
AREA VIIIcW											
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (Tonnes)	0	1	3	9	17	11	3	2	1		46
% Biomass	0.0	1.8	5.6	18.9	36.1	24.6	6.2	5.0	1.8		100
Abundance (N in '000)	0	12	33	106	195	125	31	24	8		534
% Abundance	0.0	2.2	6.1	19.9	36.5	23.5	5.8	4.5	1.5		100
Medium Weight (gr)	0.0	69.2	78.2	81.7	85.1	90.2	92.3	97.1	104.3		74.2
Medium Length (cm)	0.0	21.4	22.3	22.7	23.0	23.5	23.7	24.1	24.8		20.1
AREA IXaN											
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (Tonnes)	216	168	143	101	143	37	5	0			813
% Biomass	26.5	20.6	17.5	12.5	17.6	4.6	0.6	0.0			100
Abundance (N in '000)	6612	3004	2336	1432	1989	486	65	5			15929
% Abundance	41.5	18.9	14.7	9.0	12.5	3.1	0.4	0.0			100
Medium Weight (gr)	32.6	55.8	61.0	70.8	71.8	76.4	79.1	87.3			61.4
Medium Length (cm)	16.4	19.8	20.5	21.6	21.7	22.2	22.5	23.3			20.4
TOTAL SPAIN											
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (Tonnes)	307	666	669	469	785	332	66	39	9		3343
% Biomass	9.2	19.9	20.0	14.0	23.5	9.9	2.0	1.2	0.3		100
Abundance (N in '000)	9463	12050	11007	6384	10279	3914	757	415	82.5		54351
% Abundance	17.4	22.2	20.3	11.7	18.9	7.2	1.4	0.8	0.2		100
Medium Weight (gr)	32.4	55.3	60.8	73.5	76.4	84.8	87.7	95.0	104.8		74.5
Medium Length (cm)	16.4	19.8	20.4	21.9	22.1	23.0	23.3	23.9	24.8		21.7

The distribution of sardine eggs (obtained from the analysis of 380 CUFES stations) indicates a very coastal distribution with whole areas, e.g. Asturias (ICES sub-area VIIcE-w) and northern Galicia devoid of eggs. Total number of sardine eggs detected in Spanish waters was 5939, which represents an important increase from the 2012 values. (Figure 7)

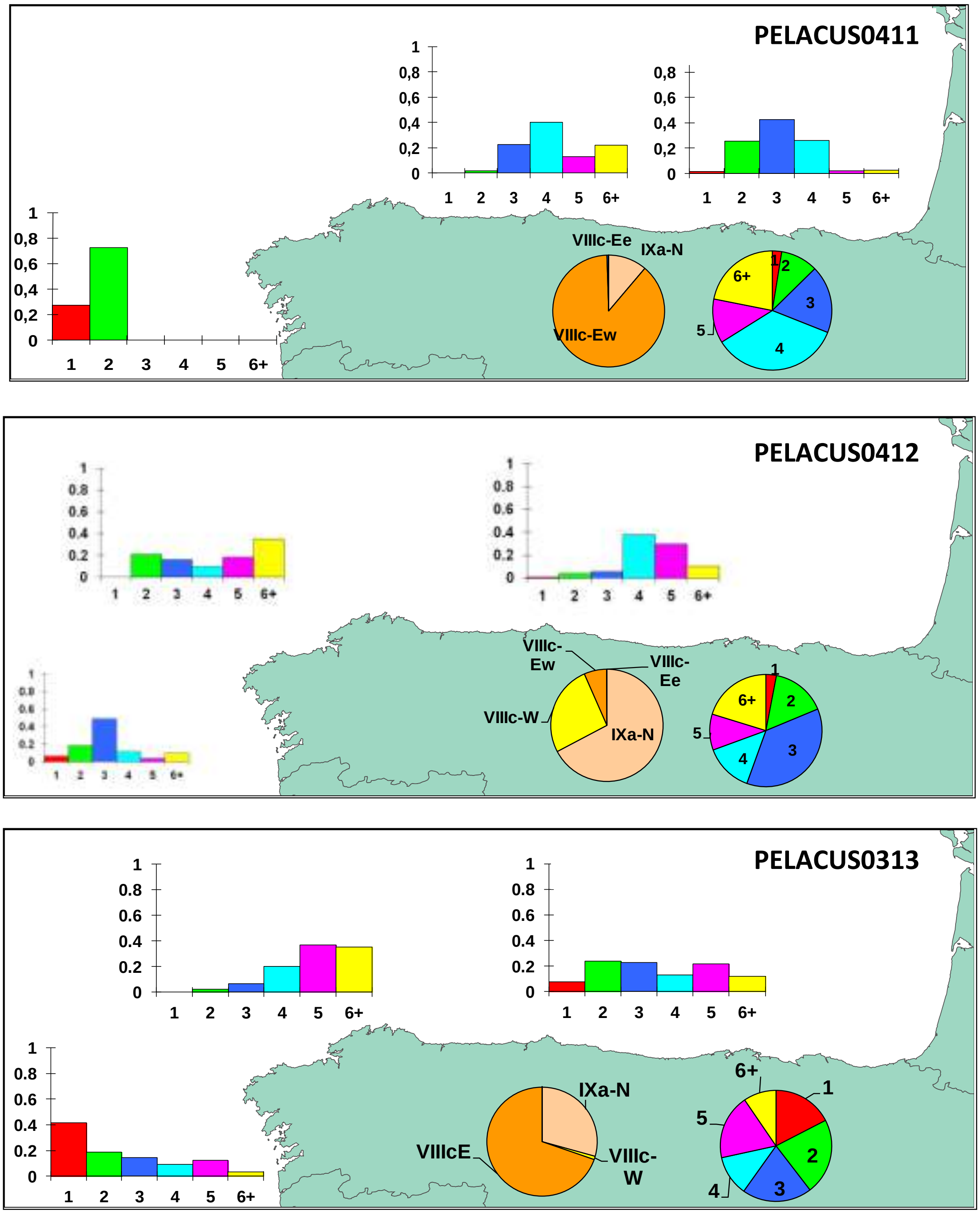

Figure 6. Sardine: relative abundance at age in each sub-area (i.e. the proportion of all age classes within sub-area sum to 1) estimated in the PELACUS spring surveys (2011-2013). The pie chart shows the contribution of each sub-area to the total stock numbers.

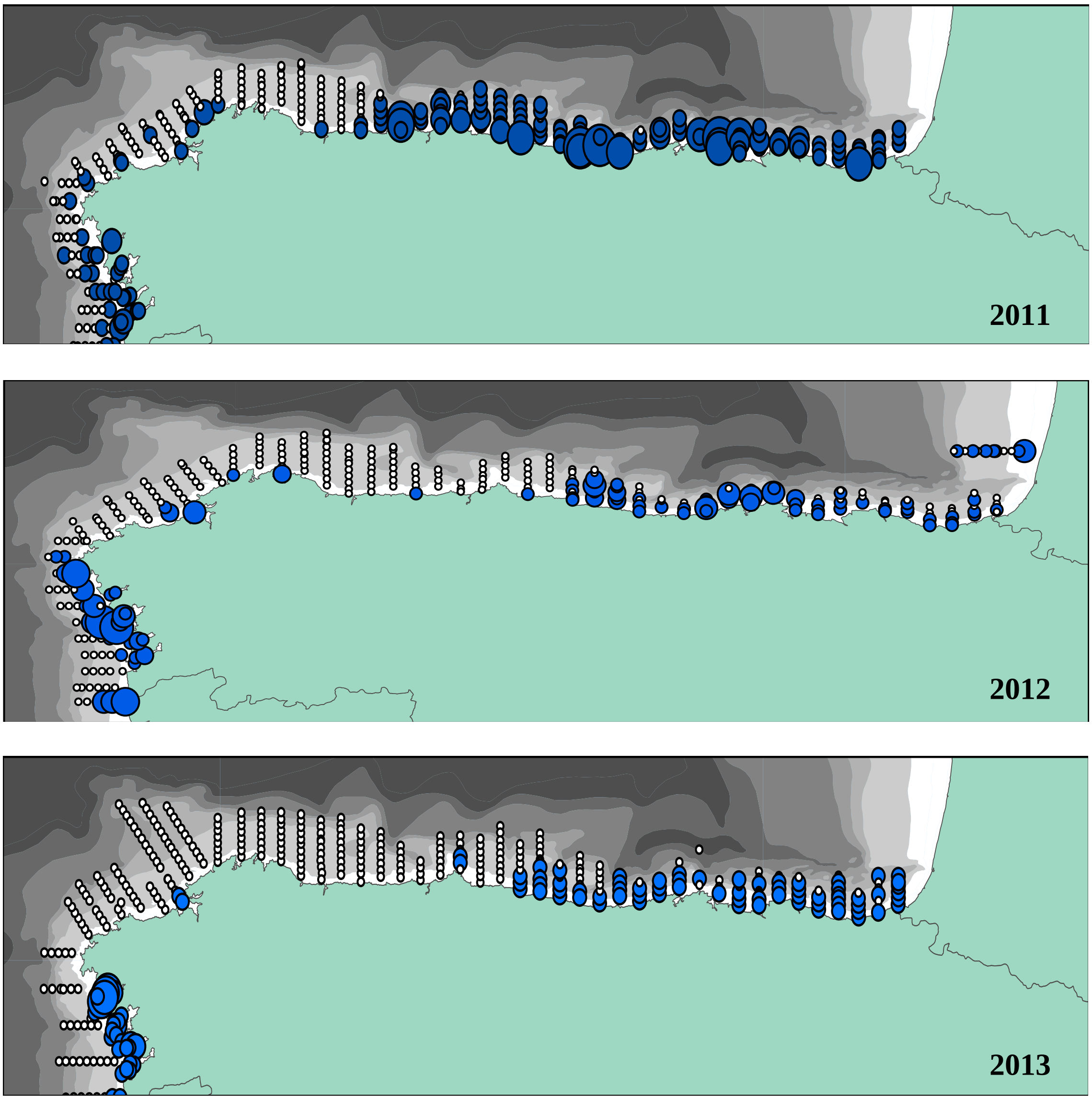

Figure 7. Sardine: distribution of eggs (CUFES samples) in 2011-2013 PELACUS surveys. Blue circles indicate positive stations with diameter proportional to egg abundance.

Discussion

PELACUS 0313 is characterised by both the bad weather conditions and the change of the R/V Thalassa by the R/V Miguel Oliver. In spite, no intercalibration was made. This exercise would be done next year. Vessel effect on acoustic assessment is very difficult to achieve when both vessels have similar characteristics (i.e. low noise radiated level). We believe vessel effect on the total NASC recorded would be negligible since no differences in fish behaviour should be expected due to the similar vessel characteristics. Another source of random error is the fishing stations which could change the species composition and/or proportion of the pelagic community. Again, the pelagic trawl with a vertical opening of about 16-18 m (20-25 in horizontal one) would have had the same performance as the Thalassa one. We had not seen any particular escaping behaviour in front of the gear and we assumed the fishing stations were ground-truthing. Unfortunately, schools close to the coast were inaccessible to the fishing gear, nor it was possible to allocate directly into fish species on account their morphological, acoustic and geographical characteristics.

On account this last feature, we were only able to properly assess the inner part of the sardine distribution (i.e. between 90 m and the self-break), and therefore a very low biomass was estimated, (3343 metric tonnes).

Nevertheless, an important amount of schools were detected close to the coast, in shallower waters in a very hard and rough sea bed, thus no accessible to the pelagic year, and these represented 33% of the total backscattering energy. Between 1992 and 2002, in coastal waters (depth <90m) sardine achieved up to 67% of the total backscattering energy (12% in deeper waters than 90 m), ranging from 40% up to 75%. If we assume that such proportion of backscattering energy for sardine in coastal waters is stable and independent of the total energy and also assuming that the sardine eggs collected in the CUFES is a good estimator of the sardine spawning biomass distribution, then the biomass estimation including an estimated proportion ranging between 30% to 60 % of the unallocated backscattering energy in coastal waters will increase the estimation in around 7 to 13 thousand tonnes (10-16 thousand tonnes in total), which is still too low.

In spite the lack of fishing stations in coastal waters allowing distributing the backscattering energy into fish species, we can conclude that the sardine biomass would remain in the lowest level of the time series, with no signal of recovery, nor of a good incoming year class in the surveyed area (IXa-North and VIIIc).

Acknowledgements

We would like to thank all the participants and crew of the PELACUS surveys.

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Sardine acoustic survey carried out in April-May 2013 off the Portuguese Continental Waters and Gulf of Cadiz, onboard RV "Noruega"

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ABSTRACT

The main results of the Portuguese acoustic survey directed to sardine and anchovy estimates in ICES sub area IX shows a reduction in sardine and anchovy biomass. The sardine abundance was the lowest of the time series, following the tendency of the last years. In the Occidental north zone (OCN), the estimated biomass was very low (9 thousand tonnes). Age 1 was predominant in the survey area although the absolute number was very low indicating a low 2012 recruitment.
The anchovy abundance suffered a strong reduction in the west coast area. On the contrary in the South coast, anchovy biomass shows a recovering, in relation to the last year. Age 1 anchovy was predominant in the north while age 2 was predominant in the south.

The 2013 spring acoustics survey took place one month later than planned and lasted longer than usual due to bad weather during the north area coverage. Although the acoustic coverage was interrupted several times, the survey itself was done in good conditions and we considered the estimate is comparable with previous surveys.

The CUFES egg distribution matched the sardine acoustic energy mapping. The higher egg abundances also coincided with the major schools found over the Promontório da Estremadura, south of Peniche.

INTRODUCTION

This paper presents the main results of the Portuguese acoustic survey carried out from 5 April to 15 May, onboard R. V. "Noruega". The objectives of the survey were to estimate the spatial distribution and the abundance of sardine (*Sardina pilchardus*) and anchovy (*Engraulis encrasicolus*) by length classes and by age groups, in the surveyed area. All the 69 planned acoustic tracks were performed. Fish egg and larvae distributions, and surface, temperature, salinity and fluorescence were also monitored along the acoustics track. The European DCF supports this survey.

MATERIAL AND METHODS

Survey execution and abundance estimation followed the methodologies adopted by the WGACEGG ICES working group. The surveyed area, limited by 20 m and 200 m isobaths, was covered following a parallel grid with a mean distance between transects of 8 nautical miles. Average survey speed was 9-10 knots and the acoustic signals were integrated over one nautical mile intervals. Echo integration was carried out with a Simrad 38 kHz EK500 scientific echo sounder. The acoustic data was recorded in MOVIES+ (Weill *et al*., 1993), which was also used to integrate the fish acoustic energy. The echogram bottom was manually corrected prior to the acoustic energy extraction. In the beginning of the survey, an acoustic calibration with a copper sphere was carried out, following the standard procedures (Foote *et al.*, 1981). For presentation purposes and results comparison, the surveyed area was divided, as usual, into 4 sub-areas or regions: OCN (from Caminha to Nazaré), OCS (from Nazaré to Cape S. Vicente), Algarve (from Cape S. Vicente to V. R. Santo António) and Cadiz (from V. R. Santo António to Cape Trafalgar).

To collect the biological data, a pelagic and a bottom trawl were used. The trawl samples were also used to identify the species and to split the acoustic energy by species and by length, within each species. Fishing was carried out according to the echogram information. Nevertheless, due to the presence of fixed commercial fishing gears it was not always possible to make hauls in some areas. Biological sampling of sardine and anchovy was performed in each haul. Sardine and anchovy otoliths were collected and used for age reading and for the production of the Age Length Keys (ALK's). For each species, the abundance (x 1 000) by age group and area was estimated from the combination of the ALK and the estimates of abundance at length from the echointegration in each area.

Fish egg and larvae were collected using the CUFES system (335 µm mesh net). The water was pumped, from 3 m depth, underway along the acoustics transects; plankton samples were taken every 3 miles. Concurrently, data on surface temperature, salinity and fluorescence were acquired by the sensors associated with the CUFES sampler and GPS information gathered from the vessel system; compilation was carried out using the EDAS software.

RESULTS

TRAWL HAULS

During the survey 26 trawl hauls were performed (Figure 1); 17 of these hauls had sardine sampled and 8 of them had anchovy sampled. The most abundant species fished were chub mackerel (*Scombrus colias*), horse mackerel (*Trachurus trachurus*) and bogue (*Boops boops*). Sardine was usually captured together with these pelagic species. Off the south coast, mediterranean horse mackerel (*Trachurus mediterraneus*) and blue jack mackerel (*Trachurus picturatus*) were also found. Anchovy was mainly found off Cadiz and eastern Algarve coast. A relative small distribution patch was found in the west coast, near Figueira da Foz.

SPATIAL DISTRIBUTION

Sardine

As seen in Figure 2, sardine was distributed all over the coast, but in small quantities. Most of the sardine was distributed in the area south of Peniche.

Anchovy

Anchovy was distributed mainly in the Algarve and Cadiz zones, sharing the space with other pelagic species (Figure 1). In the remaining area, anchovy was practically absent, with a distribution patch near Figueira da Foz.

ABUNDANCE ESTIMATES

Sardine

The estimated biomass for the Portuguese coast was 91 thousand tonnes corresponding to 3797 million individuals, the lowest value in the survey series (Figure 3). In the OCN area the sardine estimated abundance was very low (9 thousand tonnes; 254 million individuals), and was found mixed with other pelagic species. On the contrary in the OCS area sardine mainly concentrated south of Peniche, where its abundance was relatively high (72 thousand tonnes; 1575 million individuals). Algarve was scarce in sardine abundance with an estimation of 9 thousand tonnes (197 million individuals). The sardine abundance in Cadiz area was also low (21 thousand tonnes; 493 million individuals).

Anchovy

The total anchovy biomass estimated was 16 thousand tonnes (1147 x 10^6 individuals), and was mainly found in Cadiz and eastern part of Algarve. In the 2011 survey, anchovy was only found in the OCN zone (27 thousand t). The biomass in this area declined to 4 thousand tonnes.
Anchovy with age 1 to 4 years was found in the survey area. The modal age was 1 year in OCN and 2 years in both Algarve and Cadiz (Figure 6).

SARDINE LENGTH AND AGE STRUCTURE

The sardine length structure in the OCN area was predominantly unimodal (16 cm mode), with juveniles (individual total length ≤ 16 cm) contributing with 51%. In the OCS zone the length structure was clearly bimodal; 34% of sardines in the OCS area were juveniles. In Algarve and in the Cadiz areas, juveniles represented only 4% of the sardine abundance estimated for these areas (Figure 2).

Age 1 is predominant in all areas (except Algarve). However, the total abundance of age 1 fish (1800 thousand fish), corresponding to the survivors of the 2012 cohort, is 1/10th of the abundance of the 2004 strong cohort at the same age.

ENVIRONMENTAL SETTING

The weeks before the 2013 survey and also the first half of it were characterized by unsettled weather conditions with heavy rain and periods of quite strong winds that varied in direction frequently. The distributions of temperature, salinity and fluorescence (Figure 7) reflected well the atmospheric and oceanographic scenery encountered. Following above average fresh water runoff the plumes of the major rivers were very evident and quite extended over the shelf, strong phytoplankton biomass (~ fluorescence), and zooplankton (not shown) was associated with these water masses. Surface water temperature in the NW region was lower than during other surveys carried out in similar period.

SARDINE EGG DISTRIBUTION

The CUFES samples are being analysed and therefore it is not possible at this stage to present the sardine egg distribution for the whole area of the survey. For the region north of Lisbon (figure 8) the egg distribution matched the sardine acoustic energy mapping (figure 2) that highlighted a very coastal distribution in particular north of Cape Carvoeiro. The higher egg abundances also coincided with the major schools found over the Promontório da Estremadura, a region were spawning is recurrent. In the area already analysed the average egg abundances in 2013 were very similar to the ones observed during the last survey in 2011 (and also in 2007) and higher than in 2010; the higher average egg densities were observed in 2008 and 2009. The number of stations with eggs in 2013 was considerably higher (60%) than in 2011 (27%), in fact it is, for this region, one of the largest spawning areas of the survey series however this may have resulted of egg advection due to the oceanographic conditions prevalent during this year´s campaign.

During another survey carried out earlier this year, in mid February (Figure 9), the sardine egg abundances estimated from CalVET sampling (grid sparser than usual) showed a patchy pattern with the southern region with more continuous distribution than over the northern shelf; average egg density was slightly lower than during the 2011 sardine DEPM survey. The water temperature (not shown), in particular in the NW region, in February this year was lower than in previous winters.

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Table 1 – Sardine: Abundance (million) in each zone, Portugal and total area, for the acoustic surveys carried out between May 1995 and April 2013.

Survey	OCN	OCS	Algarve	Cadiz	Portugal	Total Area
SAR95MAI	1627	2117	2661	4113	6405	10518
SAR96FEV	1037	2718	2148	3523	5903	9426
SAR96JUL	3105	2914	1986	2673	8005	10678
SAR97MAR	4760	3735	1904	3558	10399	13957
SAR97NOV	2801	3447	1908	-	8156	-
SAR98MAR	4750	3129	1282	2279	9161	11440
SAR98NOV	7072	4421	2018	7657	13511	21168
SAR99MAR	4447	831	862	5495	6140	11635
SAR99NOV	3402	1599	1537	1328	6538	7866
SAR00MAR	3685	2715	1011	4463 (65%)	7411	11875 *
SAR00NOV	29399	2984	723	2909	33106	36015
SAR01MAR	13531	3093	1107	3547	17223	20770
SAR01NOV	7918	6542	1751	9765	16210	25976
SAR02MAR	7963	3631	2871	6263	14466	20728
SAR03FEV	4861	5370	1201	1858	11433	13290
SAR03NOV	3333	2820**	626	-	6779	-
SAR04JUN	8954	1884	734	-	11572	-
SAR05ABR	16900	5900	1200	1229	24000	25229
SAR05NOV	16622	863	333	-	17818	-
SAR06ABR	9514	2856	716	3399	13086	16485
SAR06NOV	4577	1602	635	1317	6814	8131
PELAGO07	4181	1924	690	2077	6795	8873
SAR07NOV	4634	2141**	180***	2733	6955	9688
PELAGO08	3303	1493	472	1763	5268	7031
SAR08OUT	3962	555	9	3529	4526	8055
PELAGO09	5095	2589	275	1570	7959	9529
PELAGO10	4481	922	530	2928	5933	8861
PELAGO11	1889	397	465	71	2751	2821
PELAGO13	**255**	**1575**	**1968**	**493**	**3978**	**4471**

* only 65% of Cadiz area was covered

** the area between Capes Espichel and S. Vicente was not covered.

*** part of Algarve was not covered

Table 2 – Sardine: Biomass (thousand tonnes) in each zone, Portugal and total area, for the acoustic surveys carried out between May 1995 and April 2013.

Survey	OCN	OCS	Algarve	Cadiz	Portugal	Total Area
SAR95MAI	**105**	**133**	**133**	**168**	**371**	**539**
SAR96FEV	27	118	106	154	251	405
SAR96JUL	154	165	108	82	427	509
SAR97MAR	153	152	96	107	401	508
SAR97NOV	87	135	106	-	328	-
SAR98MAR	191	131	65	97	387	484
SAR98NOV	151	137	95	238	383	621
SAR99MAR	158	35	39	191	232	423
SAR99NOV	89	32	92	58	213	271
SAR00MAR	98	90	59	122 (65%)	247	370 *
SAR00NOV	555	43	31	81	629	710
SAR01MAR	333	40	24	88	408	496
SAR01NOV	281	147	55	292	483	775
SAR02MAR	233	96	105	181	434	615
SAR03FEV	153	145	60	73	359	432
SAR03NOV	95	90**	37	-	222	-
SAR04JUN	240	60	39	-	339	-
SAR05ABR	286	199	62	40	547	587
SAR05NOV	458	34	12	-	504	-
SAR06ABR	370	138	40	89	548	637
SAR06NOV	257	69	27	58	353	411
PELAGO07	215	89	40	107	344	452
SAR07NOV	258	114**	11***	133	384	517
PELAGO08	170	13	26	35	209	244
SAR08OUT	121	36	0.6	149	158	307
PELAGO09	112	84	14	84	210	294
PELAGO10	125	43	11	26	179	205
PELAGO11	90	15	20	2	125	127
PELAGO13	**9**	**72**	**9**	**21**	**90**	**112**

* only 65% of Cadiz area was covered

** the area between Capes Espichel and S. Vicente was not covered.

*** part of Algarve was not covered

Table 3 – Anchovy: estimated biomass (tonnes) for the West coast, South coast and total area.

Survey	West	South	TOTAL
April2013	**3955**	**12700**	**16655**
April2011	27050	0	27050
April 2010	1188	7395	8583
April2009	2000	24800	26800
April 2008	5500	34200	39700
April 2007	1945	38020	39965
April 2006	0	24082	24082
April 2005	1062	14041	15103
March 2002	1542	21335	22877
March 2001	368	24913	25281
March 1999	596	24763	25359

Table 4 – Anchovy: estimated abundance (billion) for the West coast, South coast and total area.

Survey	west	South	TOTAL
April 2013	**251**	**896**	**1147**
April 2011	1558	0	1558
April 2010	62	963	1025
April2009	127	2069	2196
April 2008	321	2032	2353
April 2007	103	3144	3247
April 2006	0	2247	2247
April 2005	59	1306	1365
March 2002	178	3823	4001
March 2001	38	2700	2738
March 1999	37	2079	2116

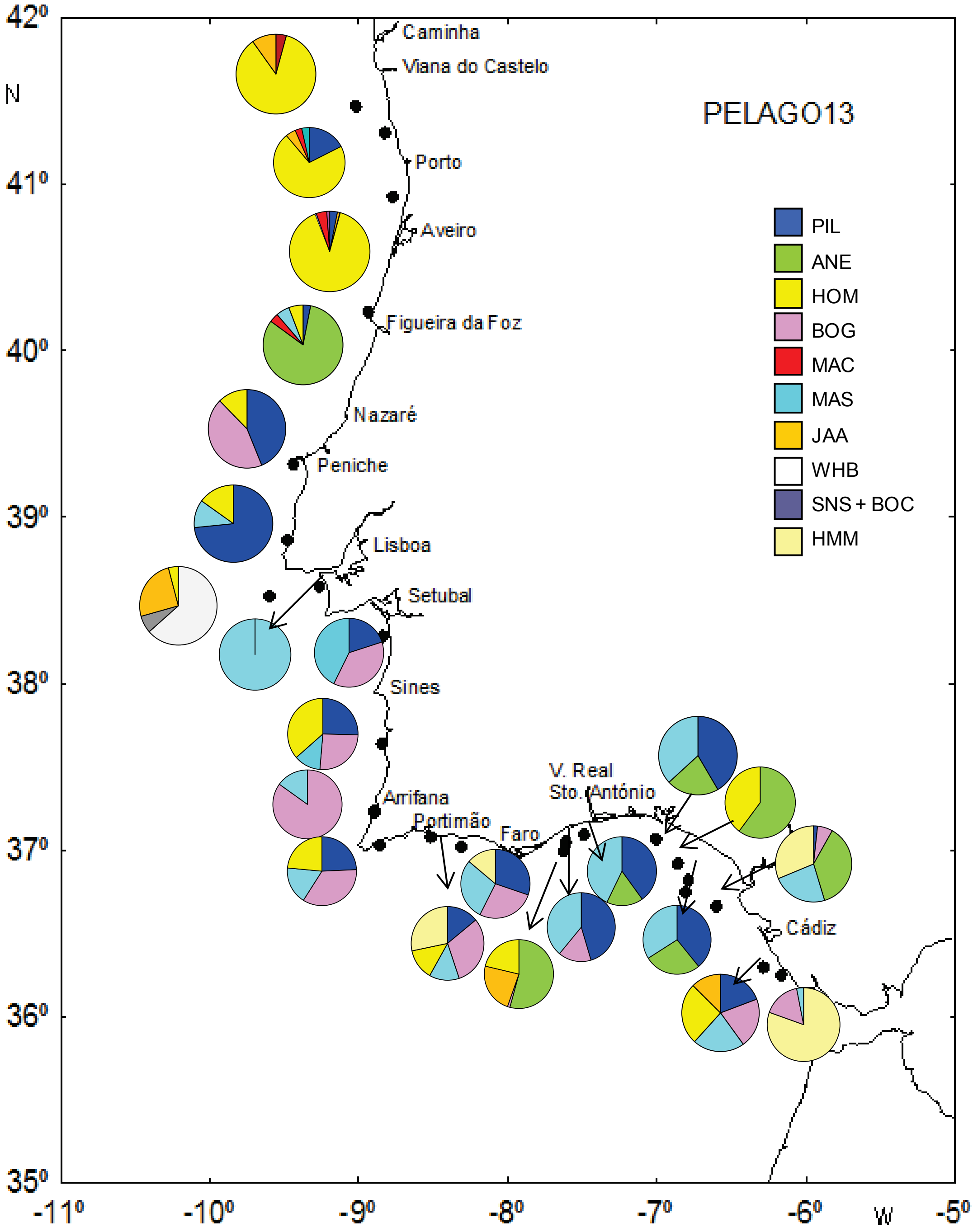

Figure 1 - Fishing trawl location and haul species composition (in number).

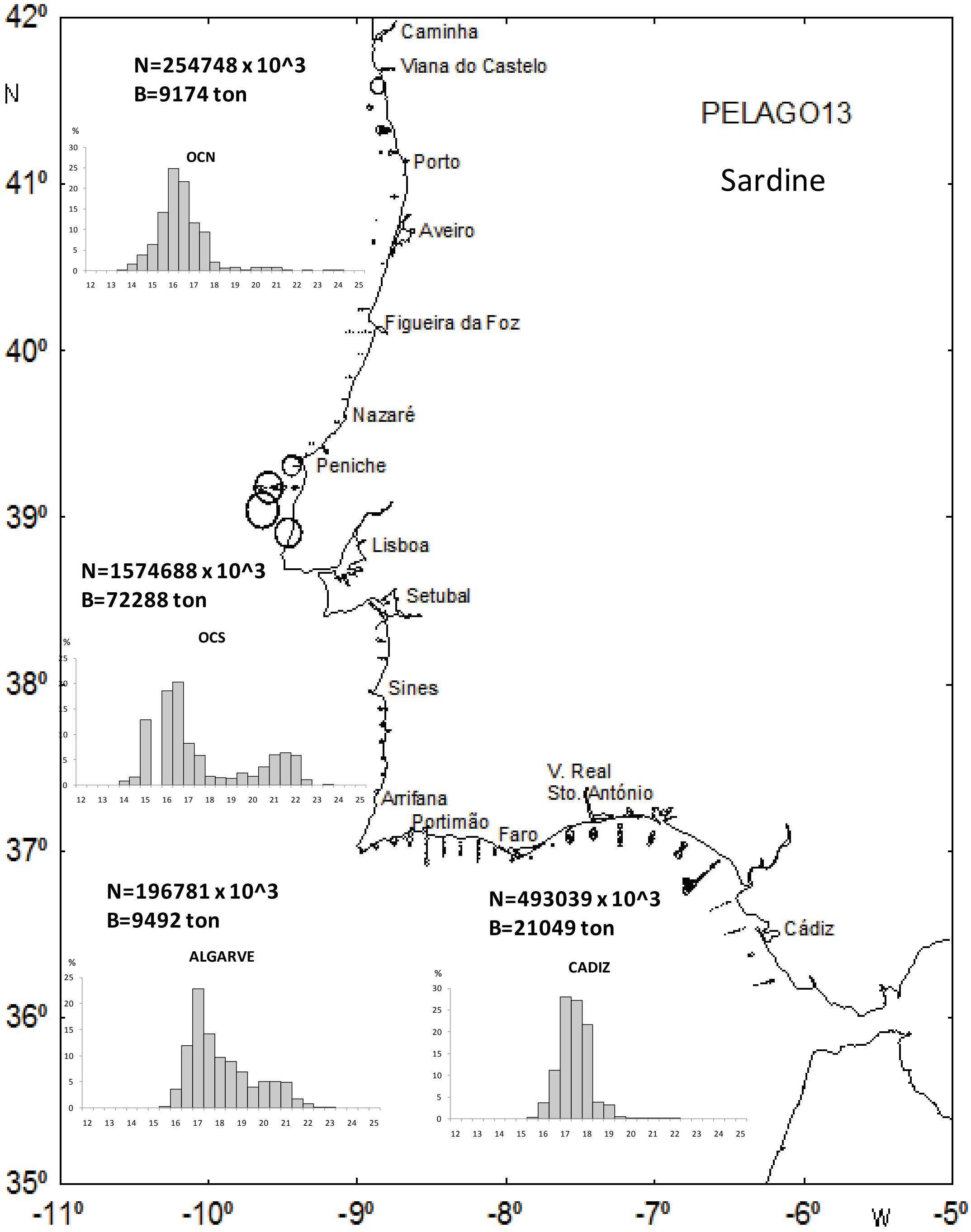

Figure 2 – Sardine acoustic energy spatial distribution. Circle area is proportional to the acoustic energy (S_A m^2/nm^2). Sardine abundance and length structure for each zone.

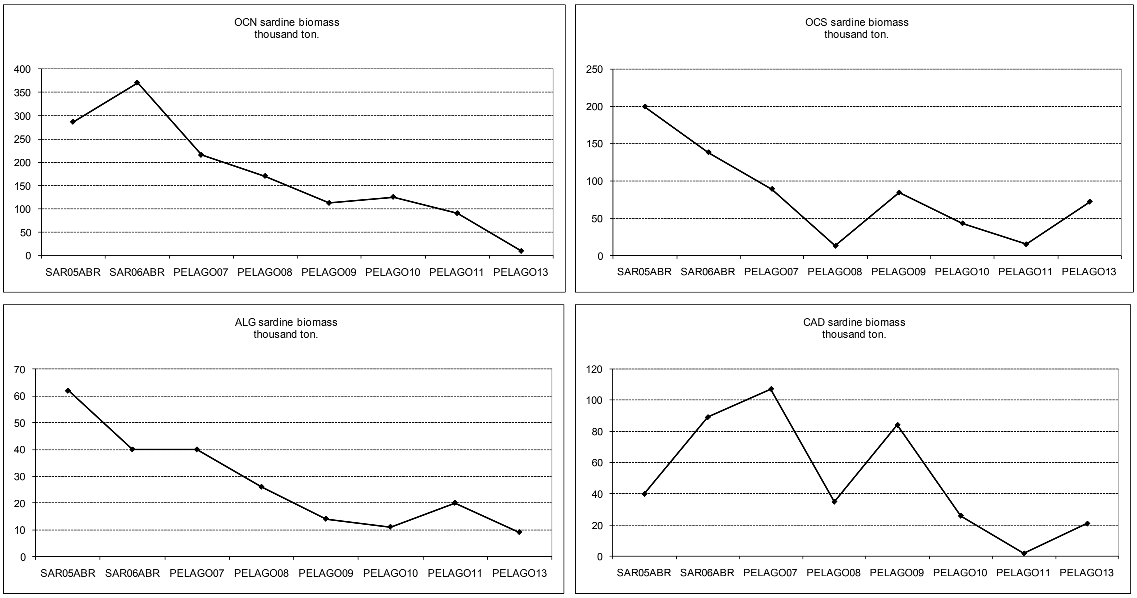

Figure 3 – Sardine biomass evolution for each zone, along the acoustic spring survey series, since 2005.

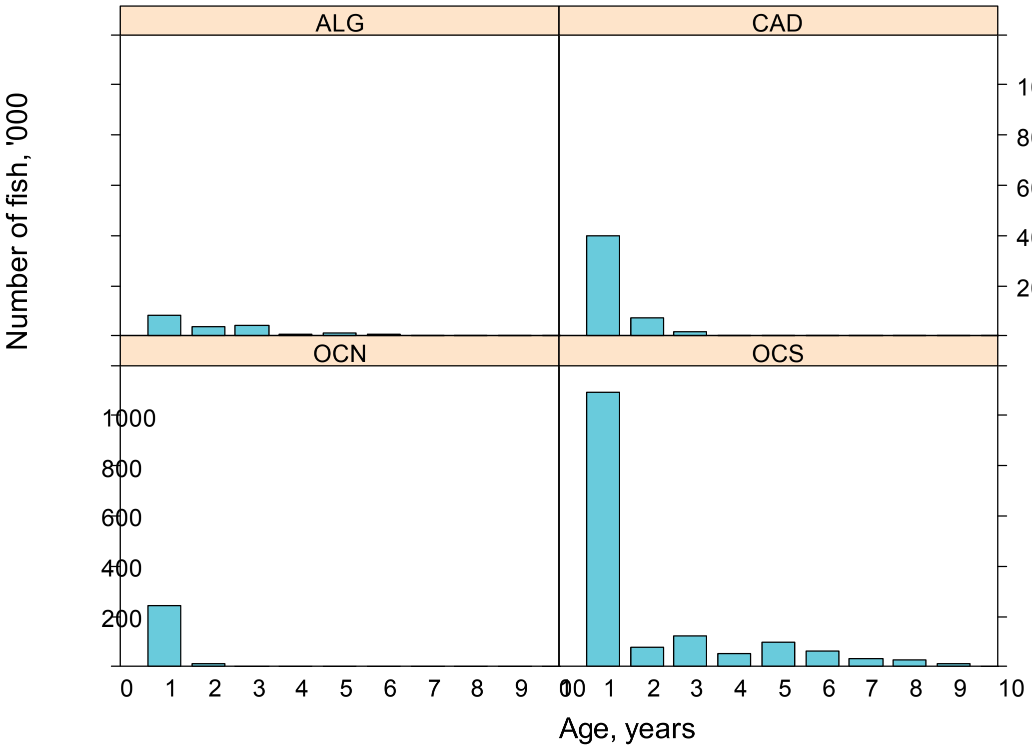

Figure 4 – Sardine abundance (x1000) per age group, for each zone.

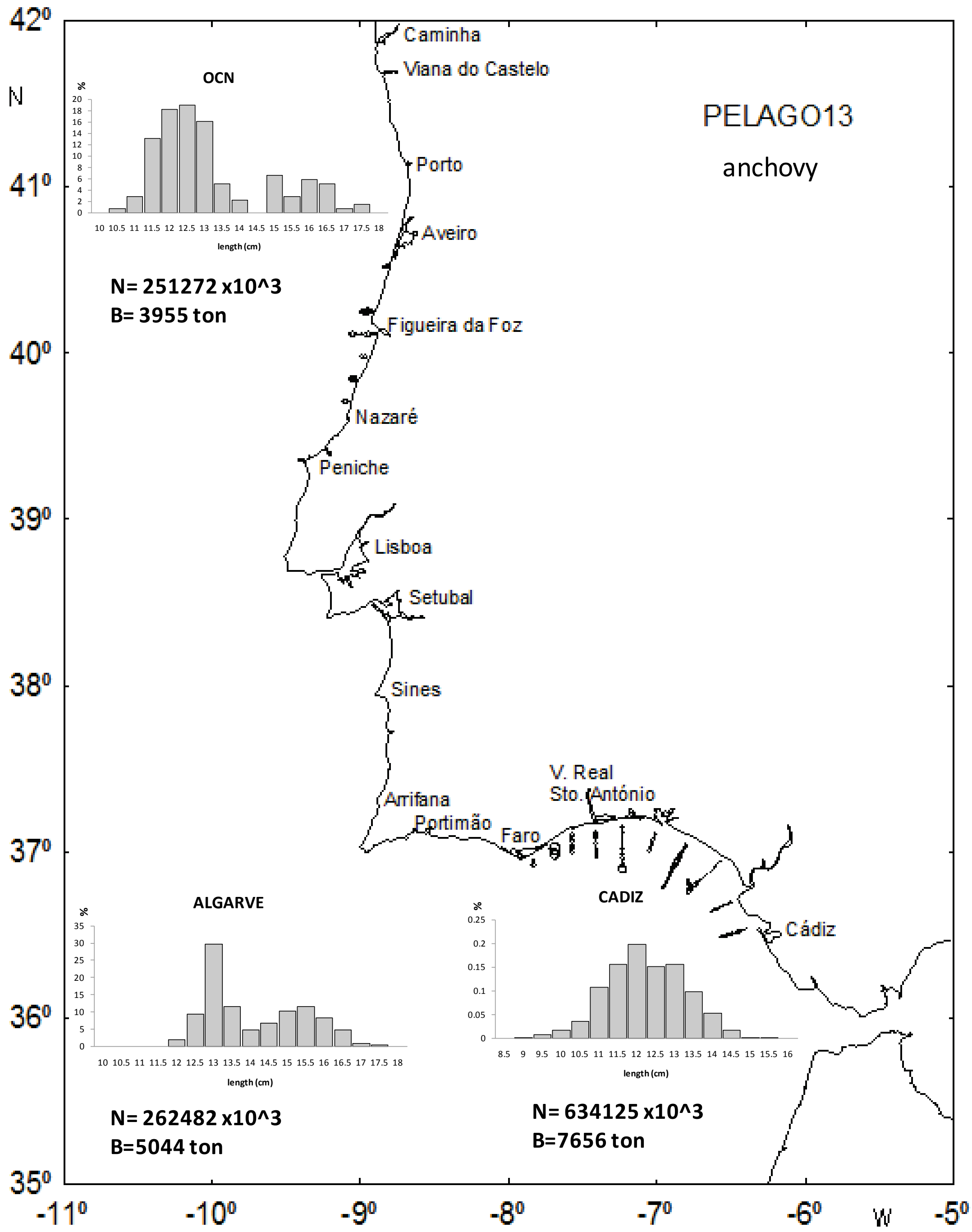

Figure 5 – Anchovy acoustic energy spatial distribution. Circle area is proportional to the acoustic energy (S_A m^2/nm^2). Anchovy abundance and length structure for West and South areas.

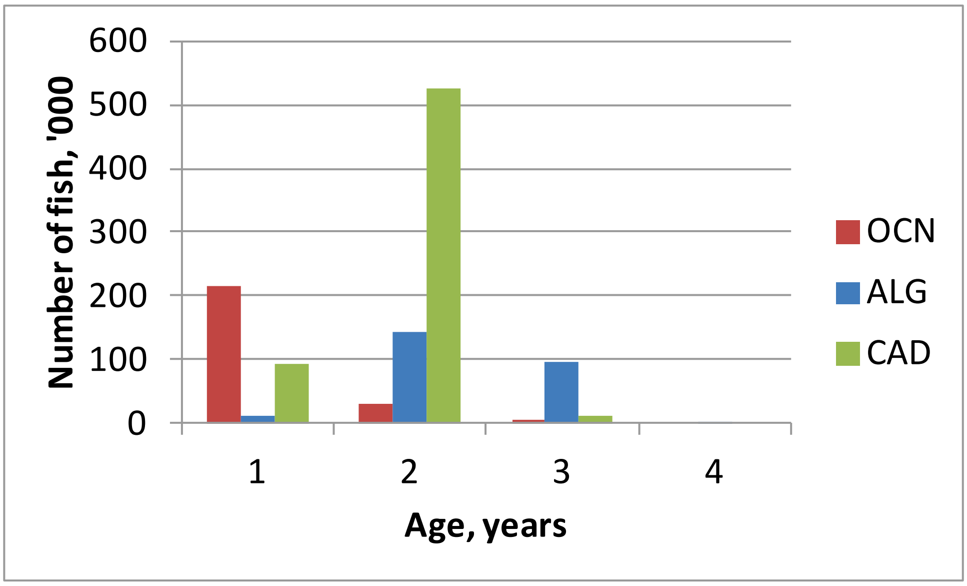

Figure 6 - Anchovy abundance (x1000) per age group, for each zone.

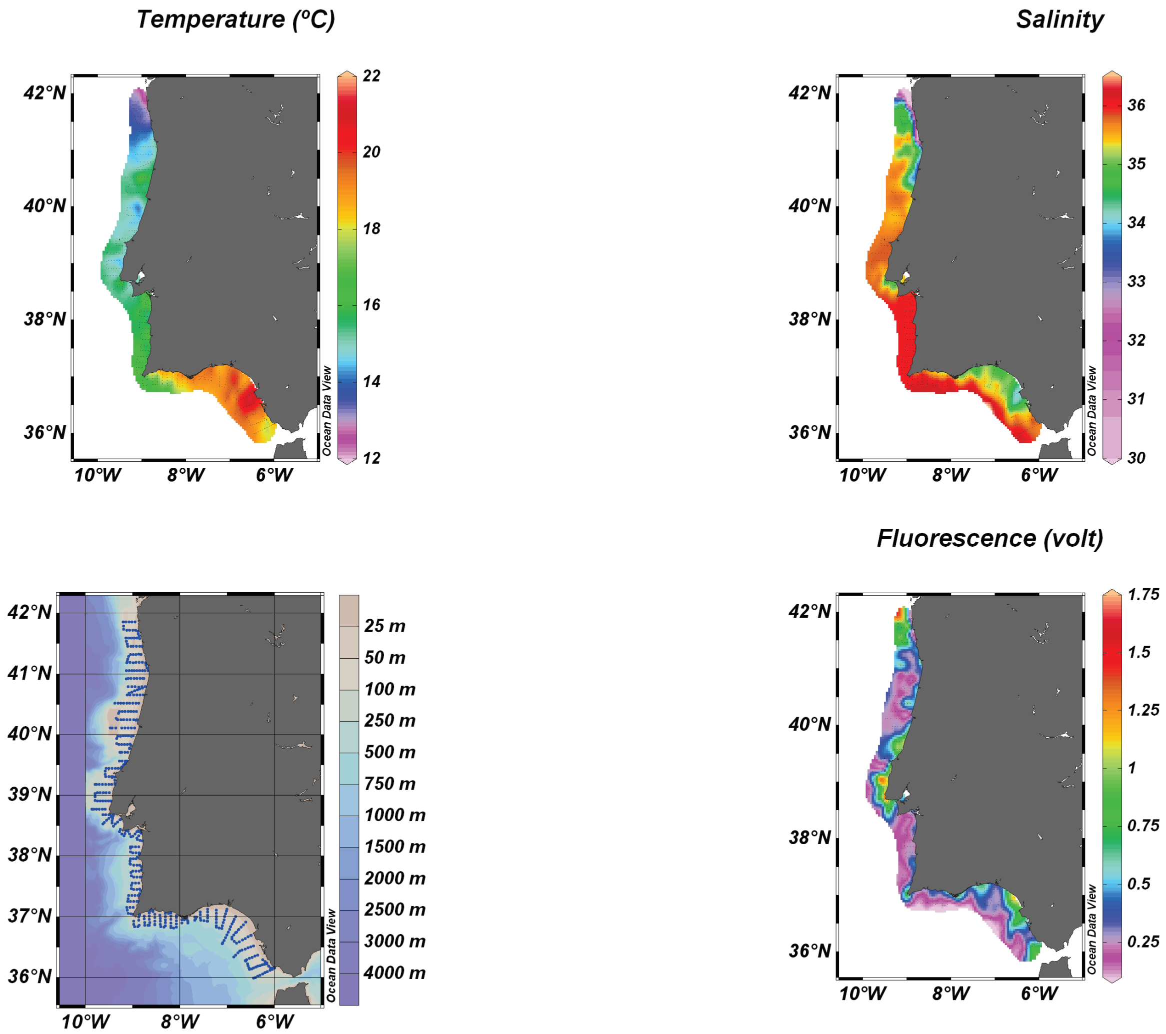

Figure 7 – Distribution of surface temperature (top left), salinity (top right) and fluorescence (bottom right). The panel at bottom left shows the CUFES stations occupied.

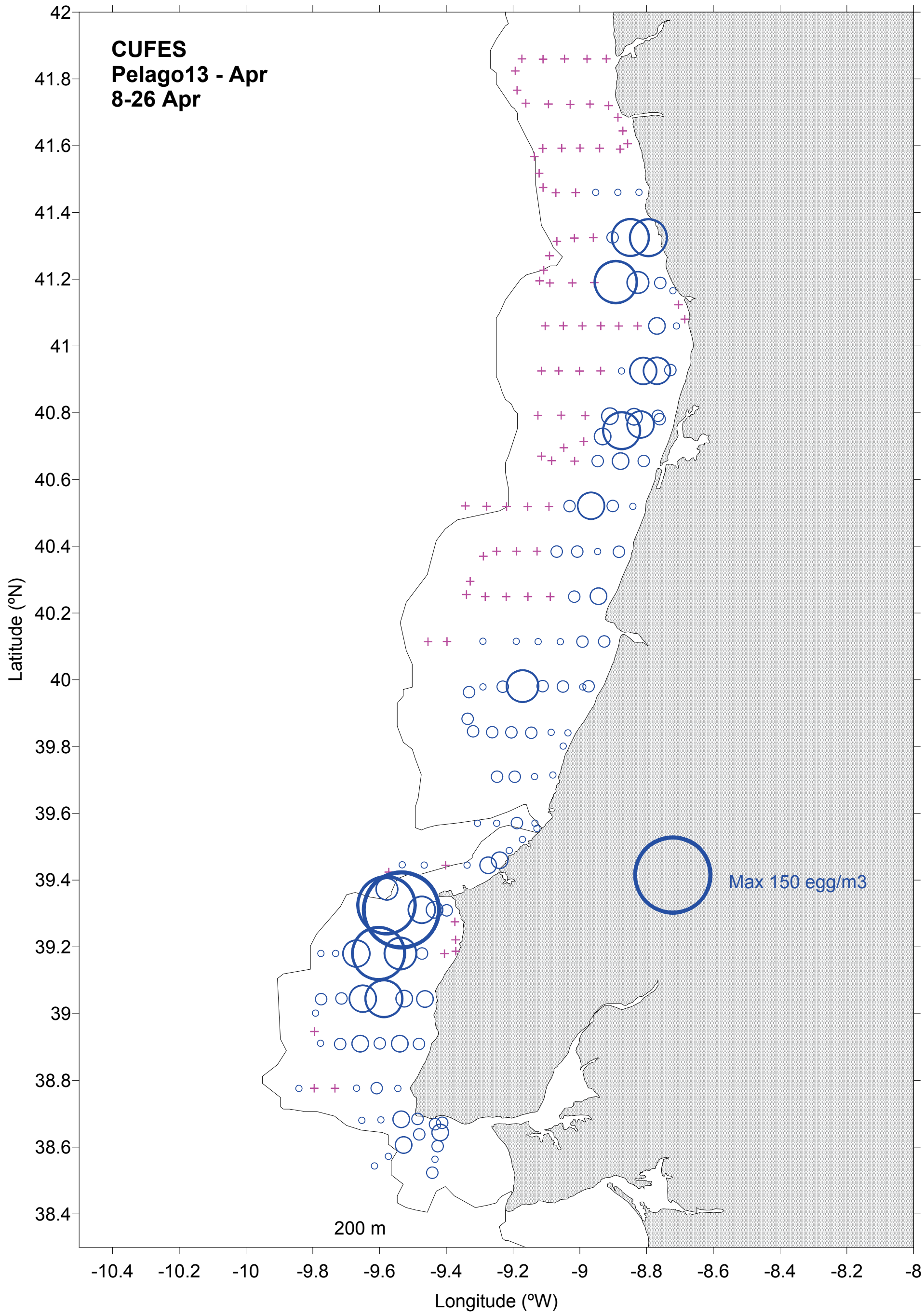

Figure 8 – Sardine egg distribution from CUFES surveying (only partially analysed at present)

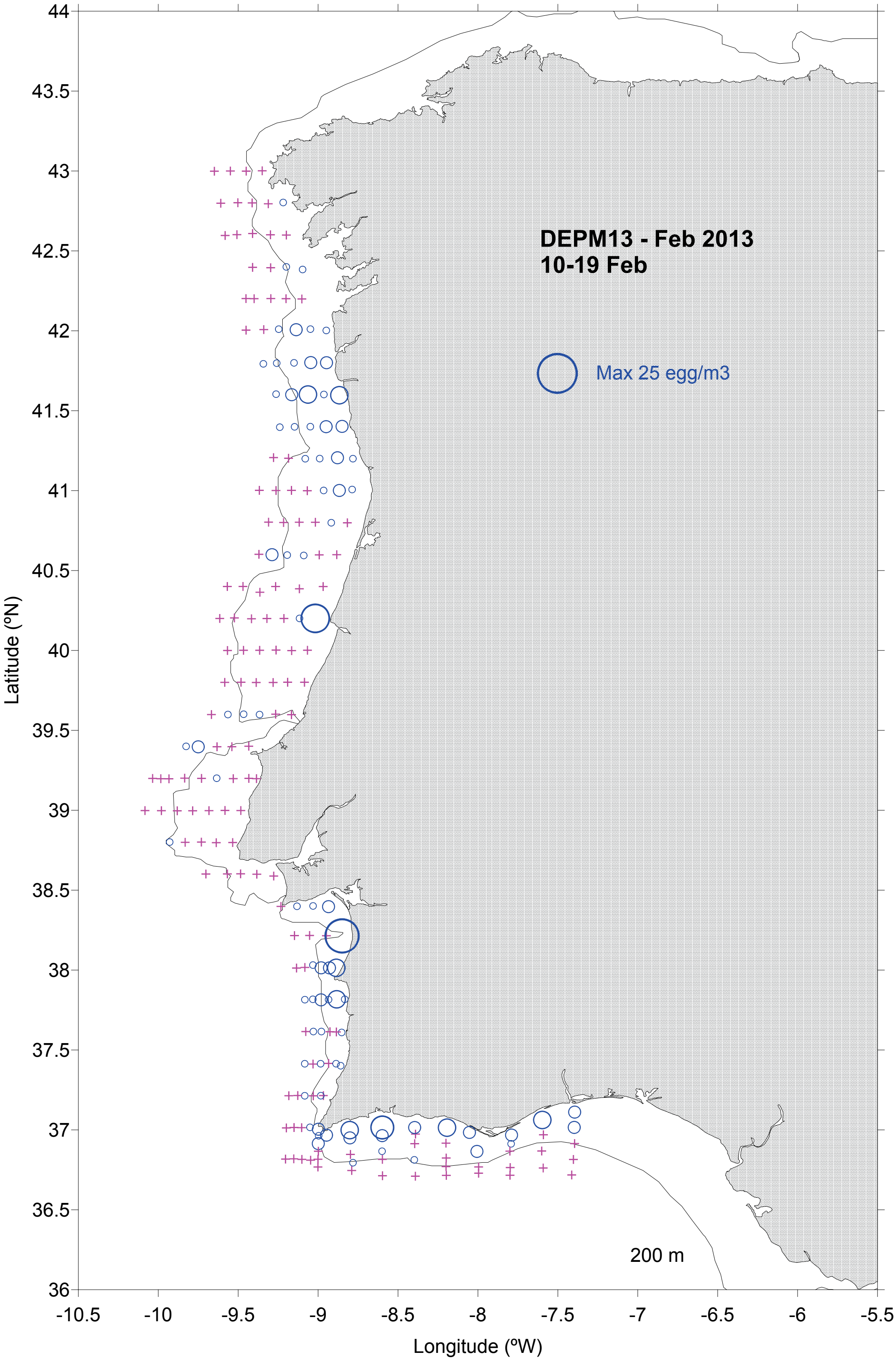

Figure 9 – Sardine egg distribution from CalVET sampling during the horse-mackerel DEPM survey in February 2013

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Acoustic assessment and distribution of the main pelagic fish species in the ICES Subdivision IXa South during the *ECOCÁDIZ-RECLUTAS 1112* Spanish survey (November 2012).

By

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ABSTRACT

ECOCÁDIZ-RECLUTAS 1112 survey is the second survey by the IEO of acoustically assessing the abundance of anchovy and sardine juveniles in their main recruitment areas off the Gulf of Cádiz. The survey was conducted between 10th and 27th November 2012 onboard the Spanish R/V *Emma Bardán* and its sampled area was restricted only to the Spanish waters of the Gulf of Cádiz between 10 and 200 m depth.

Acoustic estimates from the surveyed area were as follows:

Estimate	Anchovy	Sardine	Chub mack.	Mackerel	Horse-mack.	Medit. h-mack.	Blue jack-mack.	Bogue	Total spp.
Biomass (t)	13680	22119	11155	1136	15873	3375	976	346	68660
Abundance (millions)	2649	603	157	11	1049	148	37	7	4661

The abundance and biomass of age 0 anchovies in the surveyed area were estimated at 13 354 t and 2 619 million fish, respectively, *i.e.* 97% and 99% of the total estimated anchovy biomass and abundance. Sardine estimates were not age-structured but the abundance and biomass of juveniles smaller than 17 cm were estimated at 9 675 t and 377 millions, 44% and 62% of the total estimated species' biomass and abundance. The resulting yields and location of positive fishing stations with anchovy from a groundfish survey carried out shortly before the present survey are also shown and provide a complementary picture of the anchovy juvenile distribution during the survey season.

INTRODUCTION

During the 2007 and 2008 meetings of ICES *Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas VIII and IX* (WGACEGG) was advanced the possibility of carrying out, since 2009 on, internationally coordinated yearly surveys aimed at the direct estimation of the anchovy and sardine recruitment in the Division IXa (ICES, 2007, 2008). Conduction of such surveys would require, at least in the Gulf of Cadiz, of an appropiate acoustic sampling of the shallowest waters of its central part, an area which the conventional surveys (either Spanish or Portuguese) do not sample but, however, used to form a great part of the recruitment areas of these species.

The general objective of these surveys should initially be focused in the acoustic assessment by vertical echo-integration and mapping of the abundance and biomass of recruits of small pelagic species (especially anchovy and secondarily sardine), as well as the mapping of both the oceanographic and biological conditions featuring the recruitment areas of these species in the Division IXa. The long term objective of the surveys would be to be able to assess the strength of the incoming recruitment to the fishery the next year.

ECOCÁDIZ-RECLUTAS 1009 survey was the first attempt by the IEO of acoustically assessing the abundance of anchovy and sardine juveniles in their main recruitment areas off the Gulf of Cádiz. In order to achieve a better sampling coverage of juveniles, the acoustic sampling grid in that survey was more intensive (4 nm-spaced transects) than the adopted one in conventional surveys (8 nm-spaced transects). Unfortunately, the initially planned survey area (17 transects over waters shallower than 50 m depth between Tavira and Chipiona) and the ship-time available (11 days) showed both insufficient due to a deeper bathymetric distribution of anchovy juveniles than expected, and the succession of a series of unforeseen problems which led to drastically reduce the foreseen sampling area to only 6 transects from the easternmost zone.

The continuation of this survey series was not guaranteed for next years and in fact no survey of these characteristics was carried out in 2010 and 2011. In 2012, the *ECOCÁDIZ-RECLUTAS 1112* survey was financed by the Spanish Fisheries Secretariat and planned and conducted by the IEO with the aim of obtaining an autumn estimate of anchovy biomass and abundance in the Spanish waters of the Gulf of Cádiz. Actually, this survey sought to comply with the commitment acquired in the summer of 2012 by the Spanish Ministry with the Fisheries Sector as for the conduction of a (direct) study on anchovy in the National fishing ground of the Gulf of Cádiz. Recall that in the summer of that year IEO was unable to conduct its *ECOCÁDIZ* standard acoustic survey due to budgetary problems and IPIMAR neither conducted its *PELAGO* Spring survey.

The present Working Document summarises the main results from this survey.

MATERIAL AND METHODS

The *ECOCÁDIZ-RECLUTAS 1112* survey was carried out between 11th and 29th November 2012 onboard the Spanish R/V *Emma Bardán*. The sampled area was restricted to the Spanish waters only (11 transects, 8 nm-spaced), between 10 and 200 m depth, with the acoustic transects being the same ones that in the *ECOCÁDIZ* standard survey although extended inshore from the 20 to the 10 m depth isobaths (**Figure 1**).

Echo-integration was carried out with a *Simrad™ EK60* echo sounder working in the multi-frequency fashion (38, 120, 200 kHz). Average survey speed during the acoustic sampling was approximately 10 knots, according to the results of the vessel's self-noise tests carried out during the first day. Such a speed (corresponding to 1500 rpm) showed as the less noisy for the 38 kHz working frequency (the one used for the assessment purposes). The acoustic signals were integrated over 1-nm intervals (ESDU). Raw acoustic data were stored for further post-processing using *Myriax Software Echoview™* software package (by *Myriax Software Pty. Ltd.,* ex *SonarData Pty. Ltd.*). Acoustic equipment was previously calibrated during the *JUVENA 2012* acoustic survey, a survey conducted in the Bay of Biscay waters just before the present survey, following the standard procedures (Foote *et al*., 1987).

Survey execution and abundance estimation followed the methodologies adopted by the ICES *Planning Group for Acoustic Surveys in ICES Sub-Areas VIII and IX* (Anon., 1998) and the recommendations given by the *Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas VIII and IX* (WGACEGG; ICES, 2006b,c).

Fishing stations were opportunistic, according to the echogram information, and they were carried out using the 10-12 m-vertical opening pelagic trawl *Gloria HOD 352* at an average speed of 4 knots. Gear performance and geometry during the effective fishing was monitored with a set of *SCANMAR™ Trawl Eye-Vertical Opening-Depth* sensors which were operated by a combination of *SCANMAR™* portable hydrophone and *ScanBas* desk unit.

Trawl samples provided biological data on species and they were also used to identify fish species and to allocate the back-scattering values into fish species according to the proportions found at the fishing stations (Nakken and Dommasnes, 1975). The *PESMA 2010* software (J. Miquel, unpublished) implemented the needed procedures and routines for the acoustic assessment following the above approach.

Length frequency distributions (LFD) by 0.5-cm class were obtained for all the fish species in trawl samples (either from the total catch or from a representative random sample of 100-200 fish). For the purpose of the acoustic assessment it was only considered those size distributions based on a minimum of 30 individuals.

Due to the shortage of the scientific staff onboard the Individual biological sampling (length, weight, sex, maturity stage, stomach fullness, mesenteric fat content, otolith extraction) was performed in each haul only for anchovy.

No egg sampling by CUFES was carried out during the survey.

The following TS/length relationship table was used for acoustic estimation of assessed species (recent IEO standards after Anon., 1998; and recommendations by ICES, 2006 b, c):

Species	b_{20}
Sardine (*Sardina pilchardus*)	-72.6
Round sardinella (*Sardinella aurita*)	-72.6
Anchovy (*Engraulis encrasicolus*)	-72.6
Chub mackerel (*Scomber colias*)	-68.7
Mackerel (*S. scombrus*)	-84.9
Horse mackerel (*Trachurus trachurus*)	-68.7
Mediterranean horse-mackerel (*T. mediterraneus*)	-68.7
Blue jack mackerel (*T. picturatus*)	-68.7
Bogue (*Boops boops*)	-67.0

Unfortunately, the abovementioned shortage of scientific staff also prevented from the conduction of vertical profiles of hydrographical variables. Nevertheless, oceanographic data recorded during a previous ground-fish survey carried out in the same are shortly before (ARSA survey, 2nd-16th November) were considered as representative of the oceanographic conditions occurring during the acoustic survey. Yields from bottom-trawl fishing stations performed in that ground-fish survey were also mapped and compared with those ones from the acoustic survey in order to analyse the spatial distribution of anchovy recruits in the area.

RESULTS

Acoustic sampling

The acoustic sampling was restricted to the Spanish waters of the Gulf of Cádiz continental shelf, between 10 and 200 m depth, limited by the landmarks of Ayamonte-Isla Cristina to the west and El

Palmar-Cabo Trafalgar to the East. The acoustic sampling was carried out during the periods of 12 – 14, 21 – 23 and 25 – 26 November (**Table 1**). The successive interruptions of the acoustic sampling were caused by the occurrence of periods of bad weather and the time invested in the searching for the "Trawl Eye" net sensor (19 and 20 November). The acoustic transect R03 was repeated the 26 November for contrasting data. This transect was previously sampled the 12 November, but then showed an unusual absence of echo-traces, probably attributable to the bad sea state in previous days.

<u>Fishing stations</u>

Ten (10) fishing operations, all of them valid ones according to a correct gear performance and resulting catches, were carried out (**Table 2**, **Figure 2**). The fishing station P03 was carried out the 19 November over the transect R05, starting the effective trawling in 25 m depth towards deeper depths. After 21 minutes of trawling the gear had to be recovered because of a hawking with the bottom (probably with an artificial reef module), the gear showing damages along its entire body (but the cod-end) and in the opening and with the additional loss of net sensors. Despite such damages, the cod-end could be recovered intact and the haul considered as valid.

Because of the echo-traces usually occurred close to the bottom, all the pelagic hauls were carried out like a bottom-trawl haul, with the ground rope working very close to the bottom. According to the above, the sampled depth range in the valid hauls oscillated between 23-120 m.

During the survey were captured 4 species of Chondrichthyans, 40 species of Osteichthyes and 8 species of Cephalopods. The percentage of occurrence of the more frequent species in the valid hauls is shown in the enclosed text table below (see also **Figure 2**). Anchovy, horse-mackerel and chub mackerel (present in all the hauls) stood especially out from the set of small and mid-sized pelagic fish species. They were followed by Mediterranean horse-mackerel and sardine (8 hauls), and mackerel and blue jack mackerel (7 hauls).

Species	# of fishing stations	Occurrence (%)
Engraulis encrasicolus	10	100
Scomber colias	10	100
Trachurus trachurus	10	100
Merluccius merluccius	9	90
Sardina pilchardus	8	80
Trachurus mediterraneus	8	80
Scomber scombrus	7	70
Trachurus picturatus	7	70
Sepia officinalis	7	70
Loligo vulgaris	6	60
Loligo subulata	6	60
Boops boops	5	50
Alosa fallax	5	50

For the purposes of the acoustic assessment, anchovy, sardine, mackerels, horse & jack mackerels, and bogue were initially considered as the survey target species. All of the invertebrates, and both bentho-pelagic (*e.g.*, manta rays) and benthic fish species (*e.g.*, flatfish, gurnards, etc.) were excluded from the computation of the total catches in weight and in number from those fishing stations where they occurred. Catches of the remaining non-target species were included in an operational category termed as "*Others*".

According to these premises, during the survey was captured a total of 3 568kg and 186 thousand fish. 56**%** of the total fished biomass corresponded to chub mackerel, 19**%** to anchovy, 12**%** to sardine and

8% to horse-mackerel (**Table 3**). The most abundant species was anchovy (66%) followed by a long distance by chub mackerel (15%), horse-mackerel (11%), and sardine (6%). Mackerel, Mediterranean horse-mackerel, blue jack mackerel and bogue recorded total catches and yields almost incidental.

Back-scattering energy attributed to the "pelagic assemblage" and individual species

A total of 246 nmi (ESDU) from 11 transects has been acoustically sampled by echo-integration for assessment purposes. The enclosed text table below provides the nautical area-scattering coefficients attributed to each of the selected target species and for the whole "pelagic fish assemblage".

S_A (m^2 nmi^{-2})	Anchovy	Sardine	Chub mack.	Mackerel	Horse-mack.	Medit. h-mack.	Blue jack-mack.	Bogue	Total spp.
Total Area (%)	24473 (22.98)	15487 (14.54)	16985 (15.95)	42 (0.04)	40428 (37.96)	6009 (5.64)	2423 (2.28)	654 (0.61)	106521 (100.0)

For this "pelagic fish assemblage" has been estimated a total of 106 521 m^2 nmi^{-2}. The highest NASC values have been recorded in the inner-middle shelf, mainly in front of the sector of Mazagón-Matalascañas. The mapping of the total back-scattering energy is shown in **Figure 3**. By species, horse mackerel accounted for 38% of this total back-scattered energy, followed by anchovy (23%), chub mackerel (16%), sardine (15%), Mediterranean horse mackerel (6%), blue jack-mackerel (only 2%) and bogue and mackerel (<1%). These especies have been those ones finally assessed.

The biomass (in t) and abundance (in million fish) estimates of all the assessed species are shown in the text table below. For the whole assessed "pelagic fish assemblage" has been estimated a total of 68 660 t, which correspond to an estimated abundance of 4 661 millions of fish. Sardine was the species yielding more biomass (22 119 t), followed by horse-mackerel (15873 t), anchovy (13 680 t) and chub mackerel (11 155 t). Regarding abundance, the most abundant species was anchovy, with 2 649 millions of fish, as a direct consequence of the detection of the recruitment resulting from the spawning events occurring the last summer. The following more abundant species were horse-mackerel (1 049 millions) and sardine (603 millions).

Estimate	Anchovy	Sardine	Chub mack.	Mackerel	Horse-mack.	Medit. h-mack.	Blue jack-mack.	Bogue	Total spp.
Biomass (t)	13680	22119	11155	1136	15873	3375	976	346	68660
Abundance (millions)	2649	603	157	11	1049	148	37	7	4661

Spatial distribution and abundance/biomass estimates

Anchovy

Parameters of the survey's length-weight relationship for anchovy are given in **Figure 4**. The mapping of the backscattering energy (nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species, the positive valid fishing stations with anchovy and the coherent strata considered for the acoustic estimation are shown in **Figure 5**. The estimated abundance and biomass by size and age class are given in **Tables 4** and **5** and **Figures 6** and **7**.

The highest acoustic integrations attributed to anchovy were recorded in the central part of the study area, between Chipiona and Mazagón, mainly in the outer shelf waters in front of Doñana. Anchovy occurred in all the fishing stations but only in 7 of them the catch was representative. The estimated biomass was of 13 680 t and the abundance of 2 649 million fish (**Table 4**). According to the abovementioned distribution of the backscattering energy, the resource concentrated the bulk of its effectives in the central part of the sampled area, showing a nucleus of high density in the waters of the outer shelf in front of the coasts of Chipiona-Doñana (**Figure 5**).

The size range recorded for the species oscillated between 4.5 and 15.5 cm, with two modes, both for the abundance and the biomass estimates, at 7.5 and 10 cm (**Figure 6**). The smallest anchovies belonging to the first modal component (probably recruits from summer spawning events) were mainly recorded in the shallowest waters of the sector Cádiz Bay-Mazagón, where they were the dominant population fraction. A second nuclei of recruits with a larger size (around the second modal class at 10 cm), the most important in terms of abundance, was concentrated in the abovementioned high density area of the outer shelf waters in front Chipiona-Doñana, here sharing the space with one-year-old adult anchovies. Although 0, 1 and 2 years old fish were recorded, the bulk of the population was composed by age 0 fish (recruits; **Table 5**, **Figure 7**), with a mean size and weight for the whole sampled area of 9.47 cm and 5.79 g respectively (**Table 6**). The abundance and biomass of age 0 anchovies in the surveyed area were estimated at 13 354 t and 2 619 million fish, respectively, *i.e.* 97% and 99% of the total estimated anchovy biomass and abundance. Taking into account the estimated population age structure and the mean sizes by age class, the two modal classes observed in the population size composition evidence the co-occurrence of two pseudo-cohorts of recruits which are the result of the two main spawning events in the year (in spring and summer). These two fractions of the contingent of recruits seem to exhibit some bathymetric segregation (or, alternatively, a gradient or cline variation in the mean size) related to their ontogeny.

The biological sampling of the captured anchovies showed that 91% of the sampled females were sexually inactive (stages I and II). However, during the survey season is still possible to record males and females showing some reproductive activity (stages III, IV and V).

Sardine

Parameters of the survey's size-weight relationship for sardine are shown in **Figure 4**. The positive valid fishing stations with sardine and the coherent strata considered for the acoustic estimation are shown in **Figure 8**. Estimated abundance and biomass by size class are given in **Table 7** and **Figure 9**.

Sardine was the species that showed the highest levels of estimated biomass from all the assessed species in the area, with 22 119 t and an abundance of 603 million fish. The mapping of the backscattering energy attributed to the species evidences that sardine was mainly distributed in the western waters, close to the Portuguese border (**Figure 8**). Five positive fishing hauls were obtained that showed different size distributions, with the more coastal and easternmost sardines (PE 05, PE 06 and PE 08) being somewhat smaller in mean size (15 cm) than the ones occurring offshore and in westernmost waters (PE 07 and PE 10) with a mean size at 16.5 and 17 cm, respectively. The spatial mapping of acoustic densities and the own estimates of population abundance and biomass by coherent post-stratum indicate that the fraction of the sardine stock inhabiting the Spanish waters of the Gulf of Cádiz was concentrated during the survey in the westernmost waters (**Table 7** and **Figure 9**), with the species being almost absent in the Cádiz province waters.

The size frequency distribution of this species showed a range comprised between the 12.5 and 23 cm size classes, with two modes, both for the biomass and abundance at 14.5 and 18.5 cm (**Figure 9**). Although no age structure is available for the population estimate, the size composition of the estimated population seems to suggest that during the survey season sardine recruitment is occurring as evidenced by the first modal component at 14.5 cm. So, the abundance and biomass of juveniles smaller than 17 cm were estimated at 9 675 t and 377 millions, 44% and 62% of the total estimated species' biomass and abundance.

Chub mackerel

Parameters of the survey's length-weight relationship are shown in **Figure 4**. The positive valid fishing stations with chub mackerel and the coherent strata considered for the acoustic estimation are shown in **Figure 10**. Estimated abundance and biomass by size class are given in **Table 8** and **Figure 11**.

Chub mackerel was the fourth species most important in the area in terms of estimated biomass with 11 155 t, corresponding to 157 million fish (**Table 8**). The detected NASC for the species were concentrated over the western zone, sharing the space with sardine, and with chub mackerel being very scarce in the southeastern zone. The species was present in 6 fishing stations. The highest acoustic densities attributed to the species (and the highest abundance and biomass estimates as well) were concentrated in the central post-stratum (sector Chipiona-Mazagón) (**Figure 10**).

The size frequency distribution showed a range comprising the 15 and 26.5 cm size classes, with no clearly defined modes (**Figure 11**).

Mackerel

Parameters of the survey's length-weight relationship are shown in **Figure 4**. The positive valid fishing stations with mackerel and the coherent strata considered for the acoustic estimation are shown in **Figure 12**. Estimated abundance and biomass by size class are given in **Table 9** and **Figure 13**.

The mackerel population in Spanish waters of the Gulf of Cádiz shelf was assessed in 1 136 t and 11 million fish (**Table 9**). In contrast with its congeneric relative, mackerel showed a very feeble acoustic integration because of its absence of swim bladder and the lower occurrence in the area. The species was captured in 3 fishing stations. The spatial mapping of acoustic densities by coherent post-stratum indicates that the assessed population was only distributed in the central-western part of the sampled area, in outer shelf waters (**Figure 12**).

The size frequency distribution of the estimated population ranged between 20 and 30.5 cm, with a mode at 25 cm (**Figure 13**).

Horse-mackerel

The survey's length-weight relationship for this species is shown in **Figure 4**. Positive fishing stations and coherent strata are represented in **Figure 14**. Estimated abundance and biomass by size class are given in **Table 10** and **Figure 15**.

Horse-mackerel was a very abundant species in this survey as compared with previous estimates from standard (summer) *ECOCÁDIZ* acoustic surveys. The species ranked in the third place in terms of estimated biomass with 15 873 t and an abundance of 1 049 million fish (**Table 10**). The species was recorded all over the sampled area, standing out the acoustic integrations recorded in the central and western sectors. As indicated above, the presence index of this species in the fishing hauls was amongst the highest ones, with the species being present in 9 of the 10 valid fishing hauls. The mapping of acoustic densities by coherent post-stratum (**Figure 14**) and their respective acoustic estimates (**Table 10**) confirm to the westernmost sector of the study area as the main concentration zone of this species, dominated, moreover, by recruits.

The size frequency distribution shows a size range comprised between 10 and 24 cm, with two modes at 11.5 and 14.5 cm, both for the abundance and biomass (**Figure 15**).

Mediterranean horse-mackerel

The survey's length-weight relationship for this species is shown in **Figure 4**. Positive fishing stations and coherent strata are represented in **Figure 16**. Estimated abundance and biomass by size class are given in **Table 11** and **Figure 17**.

The species yielded an estimated biomass of 3 375 t and an abundance of 148 million fish (**Table 11**). The highest values of acoustic integration per nmi were recorded in the central and southeastern zones, with the species being absent further to the west of Mazagón. The species only occurred in 3 fishing stations. The sampled population was mainly located in the shelf waters in front of Matalascañas (**Figure 16**).

Regarding the size composition of the estimated population the species showed a size range between 9 and 36 cm, with two modal classes at 11 (the main one, composed by recruits) and 27 cm (**Figure 17**).

Blue jack mackerel

Parameters of the survey's length-weight relationship are shown in **Figure 4**. The positive valid fishing stations with mackerel and the coherent strata considered for the acoustic estimation are shown in **Figure 18**. Estimated abundance and biomass by size class are given in **Table 12** and **Figure 19**.

Blue jack mackerel yielded a biomass estimate of only 976 t and an abundance of 37 million fish (**Table 12**). The species showed an oceanic distribution, in outer shelf waters, although restricted to the westernmost sector of the sampled area. The species was captured in 5 fishing hauls (**Figure 18**).

The size frequency distribution showed a range of size classes between 11.5 and 19.5 cm, with a mode at the 15 cm size class (**Figure 19**).

Bogue

Parameters of the survey's length-weight relationship are shown in **Figure 4**. The positive valid fishing stations with mackerel and the coherent strata considered for the acoustic estimation are shown in **Figure 20**. Estimated abundance and biomass by size class are given in **Table 13** and **Figure 21**.

The acoustic estimates of both biomass and abundance of bogue (346 t and 7 million fish) evidence the incidental nature of its occurrence in the sampled area during the survey season (**Table 13**). Bogue showed a scarce acoustic integration, with only one positive fishing haul and a spatial distribution restricted to the central and eastern sectors of the surveyed area (**Figure 20**).

The size composition of the estimated population showed a size class range between 10 and 24 cm, although with a very irregular distribution (**Figure 21**). The above facts lead us to consider that the species has not been properly assessed.

DISCUSSION

The anchovy biomass has been acoustically estimated in the surveyed area at 13 680 t and its population abundance at 2 649 million fish. Age 0 anchovies (recruits) accounted for 98.9% (2 619 million fish) of the estimated total population of anchovy. Mean size and weight of these recruits were estimated at 9.47 cm and 5.79 g, respectively. The highest densities of anchovy were recorded in the central part of the surveyed area, between Chipiona and Mazagón, and more precisely in the outer shelf waters in front of Doñana coasts. The size composition and spatial distribution of anchovy recruits evidence the co-occurrence of two pseudo-cohorts within the recruits' population fraction (probably the offspring of the two main spawning events in the year in spring and summer) which seem to exhibit some bathymetric segregation (or, alternatively, a bathymetric gradient or cline variation in the mean size) related to small-scale ontogenetic inshore-offshore migrations. Thus, the smallest anchovies (around the first modal size class at 7.5 cm) were mainly recorded in the shallowest waters of the sector Cádiz Bay-Mazagón, where they were the dominant population fraction. This sector could be well identified as the core of the recruitment area and under the influence of the Guadalquivir river mouth and estuary. Larger recruits (second modal class at 10 cm), the most important in terms of abundance and biomass, co-occurred with anchovy adults (mainly age 1 fish) in the outer shelf waters in front of Doñana conforming a second recruits "wave". Such data evidence that the Gulf of Cádiz anchovy recruitment area may be well extend to deeper waters than expected (*i.e.* the coastal waters), spreading by almost the whole shelf, at least in the central part of the Gulf of Cádiz.

Figure 22 illustrates a comparative analysis of the extension of the anchovy spatial distribution as sampled by the pelagic hauls carried out in the present survey and by those bottom-trawl hauls carried out during the *ARSA 1112* ground-fish survey. *ARSA* survey dates (2nd – 16th November) were partially overlapped to the ones of the acoustic survey. The good spatial sampling coverage of the ground-fish survey yields valid information for comparative purposes, although the conduction of the fishing stations in each survey is based on different sampling schemes (opportunistic in the acoustic survey, a stratified random scheme in the ground-fish survey). Moreover, *ARSA*'s data are the only ancillary information available to the acoustic survey, since the fishery (the other source of information possible) stopped in those dates. Although the bottom-trawl gear used in the ground-fish survey (2 m vertical opening) may not be the most suitable gear to sample anchovy, the distribution pattern of the species in this last survey might give us an approximate picture of the probable general distribution of the species in the area complementary to the one given by the acoustic survey. In any case, the quasi-demersal behaviour of anchovy during the day-light hours (when both surveys are conducted) leads us to consider the bottom-trawl data as a valuable source of information. Thus, the anchovy size and age composition from bottom trawl hauls corroborates and even completes the distribution pattern of anchovy recruits in the surveyed area provided by the acoustic survey and indicate that smaller (age 0) anchovies are mainly concentrated in the same waters abovementioned described as the main core of the recruitment area. *ARSA* survey, however, seems to sample larger anchovies in the outer shelf waters than the acoustic survey, but this fact does not refute the spatial pattern described above. The potential of the *ARSA* survey series (with 2 surveys in the year, one in March and the other one in November) as an additional abundance/biomass index should be tested for its further use in the stock assessment as an alternative calibration (or recruitment) index.

The present acoustic anchovy estimates as well as those from the remaining assessed species should be considered as partial estimates for the Gulf of Cádiz since they do not include the whole of their stocks and the magnitude of these populations in the Portuguese Algarve shelf is unknown. Therefore, such estimates only will be valid when they are exclusively referred to the contingents of each stock resident in the Spanish waters. On the other hand, it is risky to issue any judgment about the magnitudes estimated as we do not have any recent estimates in similar dates. It should be remembered that the only survey with similar dates and objectives was carried out in 2009 (*ECOCÁDIZ-RECLUTAS 1109*), but problems of ship time available and sampling coverage only allowed to provide acoustic estimates for only a small part of the study area.

The same recruitment events described for anchovy were also detected for sardine and the 3 species of horse-mackerels, standing especially out amongst the carangid species the recruitment of *T. trachurus*.

During the survey occurred a high and persistent turbidity event (HPTE, see González Ortegón *et al*., 2010) in the Guadalquivir river mouth as a consequence of strong and sudden freshwater discharges

(**Figure 23**). The above authors corroborated the hypothesis that HPTEs may negatively impact the nursery function of the Guadalquivir estuary either by decreasing prey availability or by decreasing survival/arrival of marine recruits. Regarding anchovy, these authors evidenced that anchovy recruits were less abundant in the estuary during HPTEs due to significant decreases in the abundance of *Mesopodopsis slabberi*, the commonest mysid in the estuary and a key species in the estuarine food web, which is also one of the main preys of anchovy in this stage of its life cycle. This event is just being analysed by IEO oceanographers, but the probable impact of such event in the survival of the coastal biota should also be properly investigated.

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Table 1. *ECOCÁDIZ-RECLUTAS 1112* survey. Descriptive characteristics of the acoustic tracks.

Acoustic track	Location	Date	Start				End			
			Latitude	Longitude	GMT time	Mean depth (m)	Latitude	Longitude	GMT time	Mean depth (m)
R01	Trafalgar	13/11/12	36º 01.9999 N	6º 28.9999 W	10:32	121	36º 13.6710 N	6º 07.5370 W	12:29	27
R02	Sancti-Petri	14/11/12	36º 09.0000 N	6º 34.0000 W	10:01	176	36º 19.3650 N	6º 14.5219 W	15:18	15
R03	Cádiz	12/11/12	36º 27.1830 N	6º 19.1190 W	08:45	17	36º 16.5000 N	6º 37.9999 W	10:46	214
R03 bis	Cádiz	26/11/12	36º 16.5000 N	6º 37.9999 W	11:48	200	36º 27.1830 N	6º 19.1190 W	13:58	17
R04	Rota	12/11/12	36º 23.5000 N	6º 42.4999 W	11:56	189	36º 34.5120 N	6º 23.1220 W	17:32	12
R05	Chipiona	21/11/12	36º 40.1359 N	6º 29.8800 W	07:19	14	36º 31.0000 N	6º 46.5000 W	11:06	207
R06	Doñana	21/11/12	36º 37.0000 N	6º 53.1000 W	12:03	176	36º 46.4040 N	6º 35.9920 W	15:53	10
R07	Matalascañas	22/11/12	36º 44.6500 N	6º 57.0000 W	10:39	136	36º 53.5240 N	6º 40.9630 W	16:04	10
R08	Mazagón	23/11/12	37º 01.0579 N	6º 44.5849 W	08:06	14	36º 49.0999 N	7º 06.7999 W	12:14	219
R09	Punta Umbría	23/11/12	36º 49.0999 N	7º 06.7999 W	12:15	219	37º 05.0719 N	6º 55.5439 W	14:30	10
R10	El Rompido	25/11/12	37º 06.8539 N	7º 06.9030 W	08:02	12	36º 49.0999 N	7º 06.7999 W	11:56	219
R11	Isla Cristina	25/11/12	36º 52.2499 N	7º 16.6999 W	12:45	162	37º 07.7419 N	7º 16.9600 W	14:28	11

Table 2. *ECOCÁDIZ-RECLUTAS 1112* survey. Descriptive characteristics of the fishing stations.

Fishing station	Date	Acoustic track	Start		End		Depth (m)		GMT Time		Effective Trawling (min)	Total Maneuver (min)	Trawled distance (nm)
			Latitude	Longitude	Latitude	Longitude	Start	End	Start	End			
PE01	11/12/2012	R04	36º 30.8139 N	6º 29.5834 W	36º 29.6476 N	6º 31.7133 W	53,96	65,05	14:34	15:06	00:32	00:55	2,075
PE02	14/11/2012	R02	36º 12.2230 N	6º 31.4449 W	36º 09.8365 N	6º 31.3671 W	118,82	119,96	11:35	12:17	00:42	01:23	2,384
PE03	19/11/2012	R05	36º 40.0392 N	6º 30.0408 W	36º 39.3070 N	6º 31.3635 W	24,92	28,20	08:51	09:12	00:21	00:47	1,291
PE04	20/11/2012	R04	36º 31.6458 N	6º 27.0270 W	36º 30.0661 N	6º 25.5898 W	43,17	41,62	15:45	16:15	00:30	00:44	1,957
PE05	21/11/2012	R05	36º 35.3479 N	6º 38.5719 W	36º 34.0452 N	6º 40.9852 W	74,11	91,91	09:31	10:06	00:35	01:08	2,339
PE06	21/11/2012	R06	36º 43.3185 N	6º 41.6145 W	36º 42.4051 N	6º 43.2744 W	46,60	61,20	13:45	14:10	00:25	00:50	1,617
PE07	22/11/2012	R07	36º 48.3599 N	6º 50.3059 W	36º 47.1870 N	6º 52.4799 W	74,85	94,70	11:47	12:19	00:32	01:04	2,103
PE08	22/11/2012	R07	36º 52.9371 N	6º 42.0519 W	36º 51.7699 N	6º 44.2029 W	23,26	28,56	14:17	14:47	00:30	00:50	2,083
PE09	23/11/2012	R08	36º 53.3160 N	6º 59.0109 W	36º 52.3099 N	7º 00.9240 W	92,80	104,10	10:51	11:21	00:30	01:06	1,834
PE10	25/11/2012	R10	37º 02.2740 N	7º 05.9389 W	37º 02.8239 N	7º 08.3769 W	46,00	46,28	09:44	10:14	00:30	00:54	2,028

Table 3. *ECOCÁDIZ-RECLUTAS 1112* survey. Catches by species in number (upper panel) and weight (in kg, lower panel) from valid fishing stations.

Fishing station	ABUNDANCE (nº)										
	Anchovy	*Sardine*	*Chub Mack*	*Mackerel*	*Horse Mack*	*Blue Jack-Mackerel*	*Medit. Horse-Mackerel*	*Bogue*	*Longspine snipefish*	Others spp.	TOTAL
PE01	13	10	3		587	23	2	11		2	**651**
PE02	14		113	1	569	78	3		1506	7	**2291**
PE03	33		2		1		76	2		100	**214**
PE04	7033	22	23		4281	1	878	45		184	**12467**
PE05	104115	915	228	152	765	81	5			5	**106266**
PE06	4	1753	72	3	108	94	3	13		19	**2069**
PE07	2611	1057	26599	78	39	156	26	26		3	**30595**
PE08	658	99	40	1	226		109			91	**1224**
PE09	7440	8	11	52	1608	377				13	**9509**
PE10	442	7509	1041	25	11369					7	**20393**
TOTAL	**122363**	**11373**	**28132**	**312**	**19553**	**810**	**1102**	**97**	**1506**	**431**	**185679**

Fishing station	BIOMASS (kg)										
	Anchovy	*Sardine*	*Chub Mack*	*Mackerel*	*Horse Mack*	*Blue Jack-Mackerel*	*Medit. Horse-Mackerel*	*Bogue*	*Longspine snipefish*	Others spp.	TOTAL
PE01	0,069	0,456	0,645		9,73	0,527	0,021	0,142		0,167	**11,757**
PE02	0,191		4,981	0,074	7,145	1,845	1,855		7,585	1,241	**24,917**
PE03	0,076		0,34		0,03		15,02	0,316		17,867	**33,649**
PE04	17,375	0,77	1,62		64,394	0,049	19,921	2,234		23,482	**129,845**
PE05	596,803	23,1	11,978	15,4	13,784	2,448	2,101			1,117	**666,731**
PE06	0,011	57,835	5,24	0,369	2,207	2,525	0,177	0,693		3,015	**72,072**
PE07	20,921	42,821	1951,038	6,635	0,652	14,339	3,611	3,233		0,785	**2044,035**
PE08	2,62	2,61	4,34	0,188	3,76		1,7			6,174	**21,392**
PE09	68,26	0,212	0,66	6,1	28,31	7,495				1,29	**112,327**
PE10	3,682	304,92	70,023	5,374	155,793					1,671	**541,463**
TOTAL	**710,008**	**432,724**	**2050,865**	**34,14**	**285,805**	**29,228**	**44,406**	**6,618**	**7,585**	**56,809**	**3658,188**

Table 4. *ECOCÁDIZ-RECLUTAS 1112* survey. Anchovy (*E. encrasicolus*). Estimated abundance (in numbers and millions) and biomass (t) by size class, homogeneous post-stratum (Polygons, POL06 to POL01, ordered from west to east), and total area.

***ECOCÁDIZ-RECLUTAS 1112*: ANCHOVY (*E. encrasicolus*). ABUNDANCE (nº of individuals)**							
Size class (cm)	**I. Cristina-Matalascañas (offshore)**	**I. Cristina- Pta. Umbría (coastal)**	**Matalascañas (coastal)**	**Chipiona (coastal)**	**Chipiona (offshore)**	**Rota-Trafalgar**	**TOTAL**
	POL06	**POL05**	**POL04**	**POL02**	**POL03**	**POL01**	
4	0	0	0	0	0	0	0
4,5	0	0	0	7156893	0	0	7156893
5	0	0	0	14313786	0	0	14313786
5,5	0	0	0	21470679	0	0	21470679
6	0	0	11633669	57255134	0	0	68888803
6,5	0	0	0	50098248	0	12018090	62116338
7	0	0	59063211	28627567	0	62616276	150307054
7,5	0	0	118126482	14313786	0	113173747	245614015
8	0	0	70696916	7156893	33331134	60171925	171356868
8,5	0	0	70696916	14313786	50005666	28884156	163900524
9	0	0	59063211	14313786	116667935	7210855	197255787
9,5	22508252	201072	70696916	7156893	266675969	2403618	369642720
10	165501880	970986	70696916	0	241673136	0	478842918
10,5	188010121	3400097	11633669	0	150008034	0	353051921
11	76792852	5060454	23267339	0	50005666	0	155126311
11,5	22508252	4917673	11633669	0	16665567	0	55725161
12	22508252	914361	11633669	0	0	0	35056282
12,5	33100370	739351	0	0	0	0	33839721
13	10592118	221649	0	0	8337266	0	19151033
13,5	22508252	263825	0	0	0	0	22772077
14	22508252	62753	0	0	0	0	22571005
14,5	0	201072	0	0	0	0	201072
15	0	184957	0	0	0	0	184957
15,5	0	122204	0	0	0	0	122204
TOTAL	586538601	17260454	588842583	236177451	933370373	286478667	**2648668129**
Millions	**587**	**17**	**589**	**236**	**933**	**286**	**2649**

Table 4 (cont'd)**.**

ECOCÁDIZ-RECLUTAS 1112: ANCHOVY (*E. encrasicolus*). BIOMASS (t)							
Size class (cm)	**I. Cristina-Matalascañas (offshore)**	**I. Cristina- Pta. Umbría (coastal)**	**Matalascañas (coastal)**	**Chipiona (coastal)**	**Chipiona (offshore)**	**Rota-Trafalgar**	**TOTAL**
	POL 06	**POL 05**	**POL 04**	**POL 02**	**POL 03**	**POL 01**	
4	0	0	0	0	0	0	0
4,5	0	0	0	3,826	0	0	3,826
5	0	0	0	10,464	0	0	10,464
5,5	0	0	0	20,858	0	0	20,858
6	0	0	14,667	72,184	0	0	86,851
6,5	0	0	0	80,339	0	19,273	99,612
7	0	0	118,422	57,398	0	125,546	301,366
7,5	0	0	291,742	35,351	0	279,51	606,603
8	0	0	212,289	21,491	100,087	180,685	514,552
8,5	0	0	255,157	51,661	180,479	104,248	591,545
9	0	0	253,608	61,461	500,954	30,962	846,985
9,5	113,934	1,018	357,861	36,227	1349,887	12,167	1871,094
10	979,509	5,747	418,414	0	1430,322	0	2833,992
10,5	1291,352	23,354	79,906	0	1030,334	0	2424,946
11	607,998	40,066	184,216	0	395,914	0	1228,194
11,5	204,154	44,604	105,519	0	151,159	0	505,436
12	232,557	9,447	120,2	0	0	0	362,204
12,5	387,553	8,657	0	0	0	0	396,21
13	139,862	2,927	0	0	110,089	0	252,878
13,5	333,692	3,911	0	0	0	0	337,603
14	373,109	1,04	0	0	0	0	374,149
14,5	0	3,712	0	0	0	0	3,712
15	0	3,79	0	0	0	0	3,79
15,5	0	2,77	0	0	0	0	2,77
TOTAL	**4663,720**	**151,043**	**2412,001**	**451,260**	**5249,225**	**752,391**	**13679,640**

Table 5. *ECOCÁDIZ-RECLUTAS 1112* survey. Anchovy (*E. encrasicolus*). Estimated abundance (millions) and biomass (t) by age group and homogeneous post-stratum (Polygons, POL06 to POL01, ordered from west to east).

Age class	POL06	POL05	POL04	POL02	POL03	POL01	TOTAL
	N	N	N	N	N	N	N
0	558	17	589	236	932	286	2619
I	25	1	0	0	1	0	27
II	3	0,01	0	0	0	0	3
III	0	0	0	0	0	0	0
IV	0	0	0	0	0	0	0
TOTAL	586	18	589	236	933	286	2649

Age class	POL06	POL05	POL04	POL02	POL03	POL01	TOTAL
	B	B	B	B	B	B	B
0	4244.117	139.319	2414,255	448.737	5219.093	744.845	13354.358
I	376.801	11.739	0	0	18.481	0	407.444
II	46.986	0.131	0	0	0	0	47.117
III	0	0	0	0	0	0	0
IV	0	0	0	0	0	0	0
TOTAL	4667.904	151.189	2414,255	448.737	5237.574	744.845	13808.919

Table 6. *ECOCÁDIZ-RECLUTAS 1112* survey. Anchovy (*E. encrasicolus*). Mean (±SD) size (cm) and weight (g) by age class and homogeneous post-stratum (Polygons, POL06 to POL01, ordered from west to east).

Pescas	Lmed±SD		
	edad 0	edad 1	edad 2
POL 06	11.01±0.94	13.47±0.58	14.00±0.00
POL 05	11.41±0.74	14.18±1.07	14.00±0.00
POL 04	8.91±1.29		
POL 02	6.92±1.18		
POL 03	10.01±0.82	13.00±0.00	
POL 01	7.86±0.56		
Total	9.47±1.60	13.46±0.67	14.00±0.00

Pescas	Wmed±SD		
	edad 0	edad 1	edad 2
POL 06	8.84±2.94	17.77±2.41	19.99±0.00
POL 05	9.80±2.31	21.25±4.86	19.99±0.00
POL 04	4.64±2.32		
POL 02	2.09±1.27		
POL 03	6.43±1.70	15.75±0.00	
POL 01	2.90±0.72		
Total	5.79±2.99	17.75±2.56	19.99±0.00

Table 7. *ECOCÁDIZ-RECLUTAS 1112* survey. Sardine (*S. pilchardus*). Estimated abundance (in numbers and millions) and biomass (t) by size class, homogeneous post-stratum (Polygons, POL04 to POL01, ordered from west to east), and total area.

***ECOCÁDIZ-RECLUTAS 1112*: SARDINE (*S. pilchardus*). ABUNDANCE (nº of individuals)**					
Size class (cm)	**I. Cristina- Pta. Umbría**	**Matalascañas-Doñana (offshore)**	**Matalascañas-Doñana (coastal)**	**Chipiona-Cádiz**	**TOTAL**
	POL04	**POL03**	**POL02**	**POL01**	
12	0	0	0	0	0
12,5	0	0	721485	39916	761401
13	0	0	3678060	0	3678060
13,5	28122939	0	11380628	115312	39618879
14	25323568	1067943	29020854	492294	55904659
14,5	45005306	5339715	45505689	1024503	96875213
15	22481125	3203829	32374325	873711	58932990
15,5	25323568	9687772	29461482	1064419	65537241
16	11240562	9687772	10395103	341501	31664938
16,5	8441188	10755712	4663585	115312	23975797
17	11240562	7551884	3496428	0	22288874
17,5	22481125	7551884	3094481	0	33127490
18	28122939	12891601	2108956	0	43123496
18,5	33764740	7551884	6051056	0	47367680
19	39363501	3203829	0	0	42567330
19,5	16882377	0	3094481	0	19976858
20	2799374	1067943	1387472	0	5254789
20,5	2799374	0	4162414	0	6961788
21	0	0	1707010	0	1707010
21,5	0	0	721485	0	721485
22	0	0	1387472	0	1387472
22,5	0	0	721485	0	721485
23	0	1067943	0	0	1067943
TOTAL	323392248	80629711	195133951	4066968	**603222878**
Millions	**323**	**81**	**195**	**4**	**603**

Table 7 (cont'd).

ECOCÁDIZ-RECLUTAS 1112: SARDINE (*S. pilchardus*). BIOMASS (t)					
Size class (cm)	**I. Cristina- Pta. Umbría**	**Matalascañas-Doñana (offshore)**	**Matalascañas-Doñana (coastal)**	**Chipiona-Cádiz**	**TOTAL**
	POL04	**POL03**	**POL02**	**POL01**	
12	0	0	0	0	0
12,5	0	0	10,197	0,564	10,761
13	0	0	59,48	0	59,48
13,5	517,786	0	209,535	2,123	729,444
14	528,37	22,282	605,513	10,272	1166,437
14,5	1059,563	125,713	1071,344	24,12	2280,74
15	594,816	84,768	856,575	23,117	1559,276
15,5	750,162	286,982	872,74	31,531	1941,415
16	371,493	320,174	343,551	11,286	1046,504
16,5	310,211	395,269	171,385	4,238	881,103
17	457,907	307,641	142,434	0	907,982
17,5	1012,195	340,018	139,327	0	1491,54
18	1395,587	639,739	104,656	0	2139,982
18,5	1841,906	411,964	330,092	0	2583,962
19	2354,636	191,646	0	0	2546,282
19,5	1104,748	0	202,496	0	1307,244
20	199,947	76,278	99,101	0	375,326
20,5	217,777	0	323,815	0	541,592
21	0	0	144,345	0	144,345
21,5	0	0	66,186	0	66,186
22	0	0	137,825	0	137,825
22,5	0	0	77,469	0	77,469
23	0	123,741	0	0	123,741
TOTAL	**12717,104**	**3326,215**	**5968,066**	**107,251**	**22118,636**

Table 8. *ECOCÁDIZ-RECLUTAS 1112* survey. Chub mackerel (*S. colias*). Estimated abundance (in numbers and millions) and biomass (t) by size class, homogeneous post-stratum (Polygons, POL04 to POL01, ordered from west to east), and total area.

***ECOCÁDIZ-RECLUTAS 1112*: CHUB MACKEREL (*S. colias*). ABUNDANCE (nº of individuals)**					
Size class (cm)	**I. Cristina-Pta. Umbría**	**Matalascañas-Doñana**	**Chipiona-Cádiz**	**Trafalgar (offshore)**	**TOTAL**
	POL04	**POL03**	**POL02**	**POL01**	
14	0	0	0	0	0
14,5	0	0	0	0	0
15	0	507519	0	0	507519
15,5	0	0	0	32563	32563
16	0	0	0	0	0
16,5	322123	0	42362	0	364485
17	322123	507519	203338	293070	1326050
17,5	2697777	1745867	203338	455887	5102869
18	6361923	2700003	160976	1139717	10362619
18,5	3704410	3938351	406676	814084	8863521
19	2013266	5765420	245700	455887	8480273
19,5	2335389	4851886	321952	227943	7737170
20	2335389	7105272	279590	65127	9785378
20,5	1691144	10170689	42362	65127	11969322
21	4026533	10109788	0	65127	14201448
21,5	4711045	14718063	0	0	19429108
22	4026533	8262415	0	32563	12321511
22,5	3704410	9480463	0	32563	13217436
23	1328756	6516549	0	0	7845305
23,5	1691144	12139864	42362	0	13873370
24	684511	5440608	0	0	6125119
24,5	0	1827070	0	0	1827070
25	0	1278949	0	0	1278949
25,5	0	1278949	0	0	1278949
26	0	0	0	0	0
26,5	0	1278949	0	0	1278949
TOTAL	41956476	109624193	1948656	3679658	**157208983**
Millions	**42**	**110**	**2**	**4**	**157**

Table 8 (cont'd)**.**

ECOCÁDIZ-RECLUTAS 1112: CHUB MACKEREL (*S. colias*). BIOMASS (t)					
Size class (cm)	I. Cristina-Pta. Umbría	Matalascañas-Doñana	Chipiona-Cádiz	Trafalgar (offshore)	TOTAL
	POL04	POL03	POL02	POL01	
14	0	0	0	0	0
14,5	0	0	0	0	0
15	0	11,146	0	0	11,146
15,5	0	0	0	0,798	0,798
16	0	0	0	0	0
16,5	9,73	0	1,28	0	11,01
17	10,752	16,94	6,787	9,782	44,261
17,5	99,226	64,214	7,479	16,768	187,687
18	257,153	109,136	6,507	46,068	418,864
18,5	164,133	174,498	18,019	36,07	392,72
19	97,545	279,34	11,904	22,088	410,877
19,5	123,45	256,473	17,019	12,049	408,991
20	134,392	408,879	16,089	3,748	563,108
20,5	105,725	635,841	2,648	4,072	748,286
21	272,933	685,278	0	4,415	962,626
21,5	345,583	1079,656	0	0	1425,239
22	319,077	654,744	0	2,58	976,401
22,5	316,569	810,175	0	2,783	1129,527
23	122,255	599,569	0	0	721,824
23,5	167,26	1200,673	4,19	0	1372,123
24	72,665	577,556	0	0	650,221
24,5	0	207,879	0	0	207,879
25	0	155,745	0	0	155,745
25,5	0	166,472	0	0	166,472
26	0	0	0	0	0
26,5	0	189,474	0	0	189,474
TOTAL	**2618,448**	**8283,688**	**91,922**	**161,221**	**11155,279**

Table 9. *ECOCÁDIZ-RECLUTAS 1112* survey. Mackerel (*S. scombrus*). Estimated abundance (in numbers and millions) and biomass (t) by size class, homogeneous post-stratum (Polygons, POL02 to POL01, ordered from west to east), and total area.

***ECOCÁDIZ-RECLUTAS 1112*: MACKEREL (*S. scombrus*). ABUNDANCE (nº of individuals)**			
Size class (cm)	**I. Cristina-Pta. Umbría**	**Matalascañas-Rota (offshore)**	**TOTAL**
	POL02	**POL01**	
19	0	0	0
19,5	0	0	0
20	0	641261	641261
20,5	0	0	0
21	0	0	0
21,5	0	0	0
22	0	125737	125737
22,5	139989	125737	265726
23	69994	352065	422059
23,5	279978	766999	1046977
24	629949	352065	982014
24,5	419966	829868	1249834
25	139989	2275849	2415838
25,5	419966	251475	671441
26	69994	892736	962730
26,5	279978	603540	883518
27	139989	352065	492054
27,5	139989	125737	265726
28	209983	0	209983
28,5	209983	0	209983
29	209983	0	209983
29,5	69994	0	69994
30	139989	0	139989
30,5	69994	0	69994
TOTAL	3639707	7695134	**11334841**
Millions	**4**	**8**	**11**

Table 9 (cont'd).

ECOCÁDIZ-RECLUTAS 1112: MACKEREL (*S. scombrus*). BIOMASS (t)			
Size class (cm)	**I. Cristina-Pta. Umbría**	**Matalascañas-Rota (offshore)**	**TOTAL**
	POL02	**POL01**	
19	0	0	0
19,5	0	0	0
20	0	26,191	26,191
20,5	0	0	0
21	0	0	0
21,5	0	0	0
22	0	7,436	7,436
22,5	9,034	8,114	17,148
23	4,920	24,746	29,666
23,5	21,396	58,614	80,010
24	52,248	29,200	81,448
24,5	37,740	74,576	112,316
25	13,609	221,244	234,853
25,5	44,097	26,405	70,502
26	7,926	101,097	109,023
26,5	34,146	73,608	107,754
27	18,362	46,179	64,541
27,5	19,722	17,714	37,436
28	31,734	0	31,734
28,5	33,999	0	33,999
29	36,382	0	36,382
29,5	12,963	0	12,963
30	27,680	0	27,68
30,5	14,761	0	14,761
TOTAL	**420,719**	**715,124**	**1135,843**

Table 10. *ECOCÁDIZ-RECLUTAS 1112* survey. Horse-mackerel (*T. trachurus*). Estimated abundance (in numbers and millions) and biomass (t) by size class. homogeneous post-stratum (Polygons, POL04 to POL01, ordered from west to east), and total area.

***ECOCÁDIZ-RECLUTAS 1112*: HORSE-MACKEREL (*T. trachurus*). ABUNDANCE (nº of individuals)**						
Size class (cm)	**I. Cristina-Pta. Umbría**	**Matalascañas-Doñana (offshore)**	**Matalascañas-Doñana (coastal)**	**Rota-Trafalgar (offshore)**	**Chipiona-Trafalgar (coastal)**	**TOTAL**
	POL05	**POL04**	**POL03**	**POL02**	**POL01**	
9	0	0	0	0	0	0
9,5	0	0	0	0	0	0
10	0	0	1965899	0	571581	2537480
10,5	6568783	0	6389172	775548	8570368	22303871
11	65875524	201264	17338138	7755481	36513946	127684353
11,5	197579635	1189828	21269932	7561595	51203193	278804183
12	125135312	1687070	32537453	2714418	37850480	199924733
12,5	79013068	4569889	28787675	1163322	19619036	133152990
13	39506534	1485805	19131109	387774	15402102	75913324
13,5	6568783	7648052	11130993	193887	14154084	39695799
14	6568783	793219	21370044	387774	17367358	46487178
14,5	6568783	597874	21370044	0	15309820	43846521
15	0	497242	18193671	581661	11228049	30500623
15,5	0	201264	12068435	0	7886070	20155769
16	0	100632	5542743	387774	5780833	11811982
16,5	0	0	491475	193887	7713084	8398446
17	0	100632	2011406	0	1143162	3255200
17,5	0	0	1519931	0	571581	2091512
18	0	0	0	0	571581	571581
18,5	0	0	0	0	0	0
19	0	0	0	0	571581	571581
19,5	0	0	1028456	0	0	1028456
20	0	0	0	0	0	0
20,5	0	0	0	0	0	0
21	0	0	0	0	0	0
21,5	0	0	0	0	0	0
22	0	0	0	0	0	0
22,5	0	0	0	0	0	0
23	0	0	0	0	0	0
23,5	0	0	0	0	19627	19627
24	0	0	0	0	19627	19627
TOTAL	533385205	19072771	222146576	22103121	252067163	**1048774836**
Millions	**533**	**19**	**222**	**22**	**252**	**1049**

Table 10 (cont'd).

ECOCÁDIZ-RECLUTAS 1112: HORSE-MACKEREL (*T. trachurus*). BIOMASS (t)						
Size class (cm)	I. Cristina-Pta. Umbría	Matalascañas-Doñana (offshore)	Matalascañas-Doñana (coastal)	Rota-Trafalgar (offshore)	Chipiona-Trafalgar (coastal)	TOTAL
	POL05	POL04	POL03	POL02	POL01	
9	0	0	0	0	0	0
9,5	0	0	0	0	0	0
10	0	0	15,349	0	4,463	19,812
10,5	59,19	0	57,572	6,988	77,226	200,976
11	680,613	2,079	179,134	80,128	377,255	1319,209
11,5	2326,722	14,012	250,477	89,046	602,975	3283,232
12	1670,474	22,521	434,354	36,236	505,279	2668,864
12,5	1189,7	68,809	433,456	17,516	295,404	2004,885
13	667,844	25,117	323,405	6,555	260,367	1283,288
13,5	124,136	144,531	210,351	3,664	267,481	750,163
14	138,22	16,691	449,669	8,160	365,444	978,184
14,5	153,334	13,956	498,837	0	357,375	1023,502
15	0	12,832	469,502	15,01	289,749	787,093
15,5	0	5,723	343,184	0	224,252	573,159
16	0	3,144	173,157	12,114	180,595	369,01
16,5	0	0	16,820	6,635	263,965	287,42
17	0	3,763	75,207	0	42,743	121,713
17,5	0	0	61,933	0	23,290	85,223
18	0	0	0	0	25,321	25,321
18,5	0	0	0	0	0	0
19	0	0	0	0	29,73	29,730
19,5	0	0	57,784	0	0	57,784
20	0	0	0	0	0	0
20,5	0	0	0	0	0	0
21	0	0	0	0	0	0
21,5	0	0	0	0	0	0
22	0	0	0	0	0	0
22,5	0	0	0	0	0	0
23	0	0	0	0	0	0
23,5	0	0	0	0	1,921	1,921
24	0	0	0	0	2,045	2,045
TOTAL	**7010,233**	**333,178**	**4050,191**	**282,052**	**4196,880**	**15872,534**

Table 11. *ECOCÁDIZ-RECLUTAS 1112* survey. Mediterranean horse-mackerel (*T. mediterraneus*). Estimated abundance (in numbers and millions) and biomass (t) by size class. homogeneous post-stratum (Polygons, POL03 to POL01, ordered from west to east), and total area.

***ECOCÁDIZ-RECLUTAS 1112*: MEDITERRANEAN HORSE-MACKEREL (*T. mediterraneus*). ABUNDANCE (nº of individuals)**				
Size class (cm)	**Matalascañas**	**Doñana**	**Rota-Trafalgar**	**TOTAL**
	POL03	**POL02**	**POL01**	
8	0	0	0	0
8,5	0	0	0	0
9	991954	0	1966553	2958507
9,5	2975864	0	4719697	7695561
10	8927590	63008	5899621	14890219
10,5	21823002	0	4719697	26542699
11	26782768	63008	6686250	33532026
11,5	24798861	0	5112991	29911852
12	10911496	63008	786629	11761133
12,5	4959772	0	786629	5746401
13	991954	0	393295	1385249
13,5	2975864	0	0	2975864
14	0	0	0	0
14,5	0	0	0	0
15	0	0	393295	393295
15,5	0	0	393295	393295
…	…	…	…	…

Table 11 (Abundance. Cont'd)**.**

ECOCÁDIZ-RECLUTAS 1112: MEDITERRANEAN HORSE-MACKEREL (*T. mediterraneus*). ABUNDANCE (nº of individuals)				
Size class (cm)	**Matalascañas**	**Doñana**	**Rota-Trafalgar**	**TOTAL**
	POL03	**POL02**	**POL01**	
…	…	…	…	…
22	0	0	39831	39831
22,5	0	0	79663	79663
23	0	0	0	0
23,5	0	0	0	0
24	0	0	0	0
24,5	0	0	0	0
25	0	0	0	0
25,5	0	0	39831	39831
26	0	0	398314	398314
26,5	0	0	278819	278819
27	991954	0	517808	1509762
27,5	0	0	557639	557639
28	0	126015	557639	683654
28,5	0	630077	238988	869065
29	0	693084	278819	971903
29,5	0	1134138	79663	1213801
30	0	441054	0	441054
30,5	0	567069	0	567069
31	0	252031	0	252031
31,5	0	252031	0	252031
32	0	189023	0	189023
32,5	0	126015	39831	165846
33	0	0	0	0
33,5	0	0	0	0
34	0	63008	0	63008
34,5	0	63008	0	63008
35	0	0	0	0
35,5	0	63008	0	63008
36	991954	0	0	991954
TOTAL	108123033	4788585	34964797	**147876415**
Millions	**108**	**5**	**35**	**148**

Table 11 (Biomass. Cont'd)**.**

ECOCÁDIZ-RECLUTAS 1112: MEDITERRANEAN HORSE-MACKEREL (*T. mediterraneus*). BIOMASS (t)				
Size class (cm)	**Matalascañas**	**Doñana**	**Rota-Trafalgar**	**TOTAL**
	POL03	**POL02**	**POL01**	
8	0	0	0	0
8,5	0	0	0	0
9	5,596	0	11,093	16,689
9,5	19,688	0	31,225	50,913
10	68,719	0,485	45,412	114,616
10,5	194,038	0	41,965	236,003
11	273,281	0,643	68,224	342,148
11,5	288,647	0	59,513	348,160
12	144,085	0,832	10,387	155,304
12,5	73,927	0	11,725	85,652
13	16,612	0	6,586	23,198
13,5	55,749	0	0	55,749
14	0	0	0	0
14,5	0	0	0	0
15	0	0	10,081	10,081
15,5	0	0	11,115	11,115
…	…	…	…	…

Table 11 (Biomass. Cont'd)**.**

ECOCÁDIZ-RECLUTAS 1112: MEDITERRANEAN HORSE-MACKEREL (*T. mediterraneus*). BIOMASS (t)				
Size class (cm)	**Matalascañas**	**Doñana**	**Rota-Trafalgar**	**TOTAL**
	POL03	**POL02**	**POL01**	
…	…	…	…	…
22	0	0	3,204	3
22,5	0	0	6,855	7
23	0	0	0	0
23,5	0	0	0	0
24	0	0	0	0
24,5	0	0	0	0
25	0	0	0	0
25,5	0	0	4,987	4,987
26	0	0	52,862	52,862
26,5	0	0	39,179	39,179
27	147,424	0	76,957	224,381
27,5	0	0	87,567	87,567
28	0	20,888	92,432	113,320
28,5	0	110,137	41,775	151,912
29	0	127,643	51,349	178,992
29,5	0	219,869	15,444	235,313
30	0	89,930	0	89,930
30,5	0	121,509	0	121,509
31	0	56,707	0	56,707
31,5	0	59,499	0	59,499
32	0	46,786	0	46,786
32,5	0	32,678	10,329	43,007
33	0	0	0	0
33,5	0	0	0	0
34	0	18,712	0	18,712
34,5	0	19,551	0	19,551
35	0	0	0	0
35,5	0	21,305	0	21,305
36	349,816	0	0	349,816
TOTAL	**1637,582**	**947,174**	**790,266**	**3375,022**

Table 12. *ECOCÁDIZ-RECLUTAS 1112* survey. Blue jack mackerel (*T. picturatus*). Estimated abundance (in numbers and millions) and biomass (t) by size class. homogeneous post-stratum (Polygons, POL03 to POL01, ordered from west to east), and total area.

***ECOCÁDIZ-RECLUTAS 1112*: BLUE JACK MACKEREL (*T. picturatus*). ABUNDANCE (nº of individuals)**				
Size class (cm)	**I. Cristina-Mazagón**	**Matalascañas-Cádiz**	**Sancti-Petri-Trafalgar**	**TOTAL**
	POL03	**POL02**	**POL01**	
11	0	0	0	0
11,5	0	0	32754	32754
12	212203	53060	98264	363527
12,5	212203	0	229282	441485
13	689660	300458	589581	1579699
13,5	689660	0	393054	1082714
14	2281183	318358	196527	2796068
14,5	3872705	2353268	262036	6488009
15	6790497	2705826	65509	9561832
15,5	3183047	2962068	229282	6374397
16	1114066	3546895	0	4660961
16,5	689660	1503142	0	2192802
17	212203	459637	131018	802858
17,5	0	353517	65509	419026
18	0	353517	32754	386271
18,5	0	53060	98264	151324
19	0	0	65509	65509
19,5	0	0	65509	65509
TOTAL	19947087	14962806	2554852	**37464745**
Millions	**20**	**15**	**3**	**37**

Table 12 (cont'd)**.**

ECOCÁDIZ-RECLUTAS 1112: **BLUE JACK MACKEREL (*T. picturatus*). BIOMASS (t)**				
Size class (cm)	**I. Cristina-Mazagón**	**Matalascañas-Cádiz**	**Sancti-Petri-Trafalgar**	**TOTAL**
	POL03	**POL02**	**POL01**	
11	0	0	0	0
11,5	0	0	0,367	0,367
12	2,706	0,677	1,253	4,636
12,5	3,066	0	3,312	6,378
13	11,232	4,893	9,602	25,727
13,5	12,606	0	7,184	19,790
14	46,603	6,504	4,015	57,122
14,5	88,089	53,528	5,960	147,577
15	171,36	68,282	1,653	241,295
15,5	88,817	82,651	6,398	177,866
16	34,264	109,089	0	143,353
16,5	23,311	50,808	0	74,119
17	7,861	17,027	4,854	29,742
17,5	0	14,315	2,653	16,968
18	0	15,609	1,446	17,055
18,5	0	2,549	4,720	7,269
19	0	0	3,415	3,415
19,5	0	0	3,699	3,699
TOTAL	**489,915**	**425,932**	**60,531**	**976,378**

Table 13. *ECOCÁDIZ-RECLUTAS 1112* survey. Bogue (*B. boops*). Estimated abundance (in numbers and millions) and biomass (t) by size class. homogeneous post-stratum (Polygons, POL02 to POL01, ordered from west to east), and total area.

***ECOCÁDIZ-RECLUTAS 1112*: BOGUE (*B. boops*) ABUNDANCE (nº of individuals)**			
Size class (cm)	**Mazagón-Doñana**	**Chipiona-Trafalgar**	**TOTAL**
	POL02	**POL01**	
9	0	0	0
9,5	0	0	0
10	100567	47490	148057
10,5	100567	47490	148057
11	301701	142469	444170
11,5	402268	189958	592226
12	502835	237448	740283
12,5	402268	189958	592226
13	0	0	0
13,5	0	0	0
14	0	0	0
14,5	0	0	0
15	201134	94979	296113
15,5	100567	47490	148057
16	0	0	0
16,5	100567	47490	148057
17	0	0	0
17,5	402268	189958	592226
18	100567	47490	148057
18,5	0	0	0
19	502835	237448	740283
19,5	0	0	0
20	100567	47490	148057
20,5	100567	47490	148057
21	502835	237448	740283
21,5	100567	47490	148057
22	100567	47490	148057
22,5	201134	94979	296113
23	100567	47490	148057
23,5	0	0	0
24	100567	47490	148057
24,5	0	0	0
TOTAL	4525515	2137035	**6662550**
Millions	**5**	**2**	**7**

Table 13 (cont'd).

ECOCÁDIZ-RECLUTAS 1112: BOGUE (*B. boops*) BIOMASS (t)			
Size class (cm)	**Mazagón-Doñana**	**Chipiona-Trafalgar**	**TOTAL**
	POL02	**POL01**	
9	0	0	0
9,5	0	0	0
10	0,838	0,396	1,234
10,5	0,981	0,463	1,444
11	3,422	1,616	5,038
11,5	5,270	2,489	7,759
12	7,564	3,572	11,136
12,5	6,910	3,263	10,173
13	0	0	0
13,5	0	0	0
14	0	0	0
14,5	0	0	0
15	6,257	2,955	9,212
15,5	3,482	1,644	5,126
16	0	0	0
16,5	4,270	2,017	6,287
17	0	0	0
17,5	20,704	9,777	30,481
18	5,676	2,680	8,356
18,5	0	0	0
19	33,871	15,994	49,865
19,5	0	0	0
20	8,013	3,784	11,797
20,5	8,688	4,103	12,791
21	47,012	22,20	69,212
21,5	10,156	4,796	14,952
22	10,952	5,172	16,124
22,5	23,579	11,134	34,713
23	12,671	5,983	18,654
23,5	0	0	0
24	14,570	6,880	21,450
24,5	0	0	0
TOTAL	**110,918**	**234,886**	**345,804**

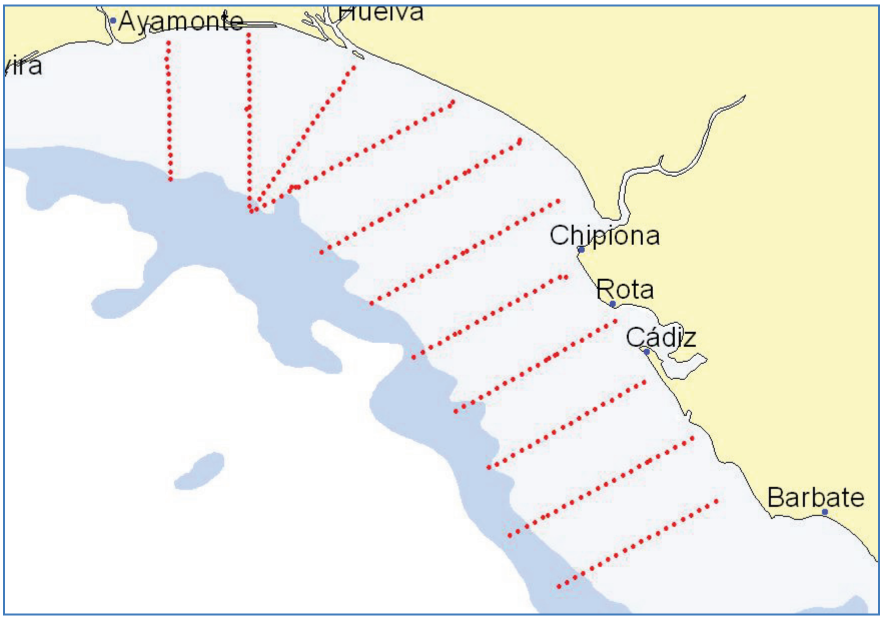


Figure 1. *ECOCÁDIZ-RECLUTAS 1112* survey. The grid of 11 transects for acoustic sampling. This set of transects corresponds to the same one sampled in the summer standard survey (ECOCÁDIZ series) but with the shallower limit extended to the 10 m depth isobaths. The sampled area in this survey only included the Spanish shelf of the Gulf of Cádiz.

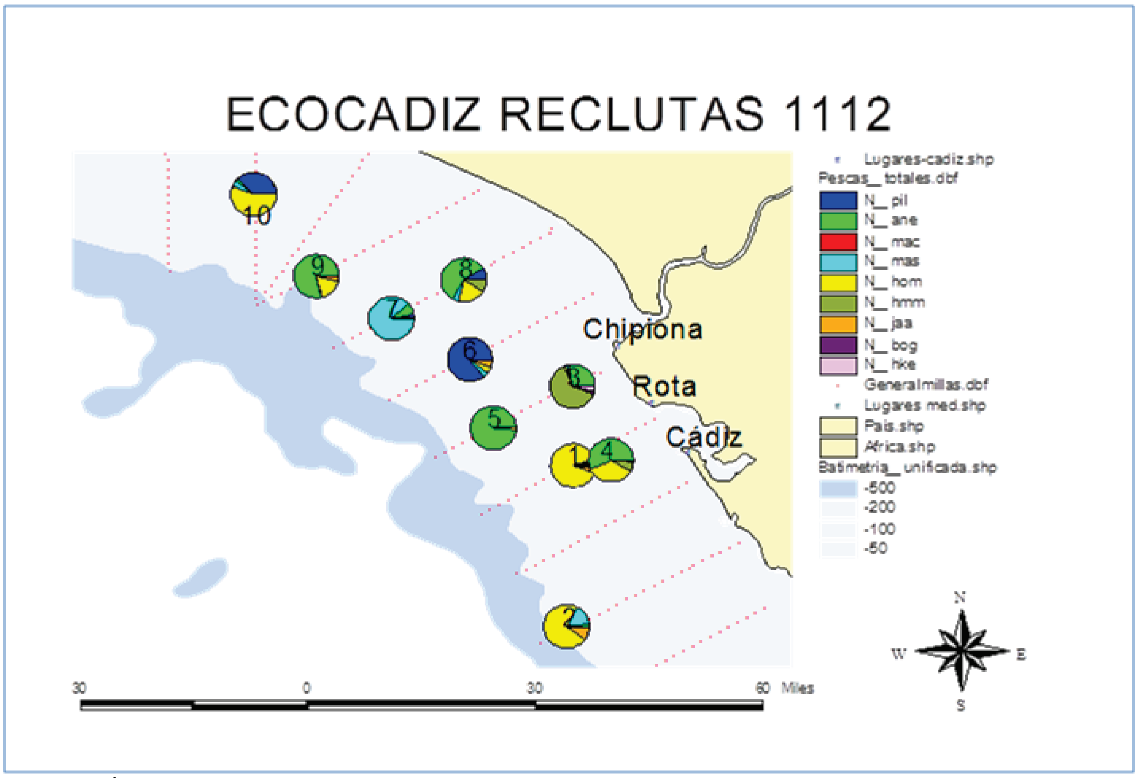


Figure 2. *ECOCÁDIZ-RECLUTAS 1112* survey. Location of valid fishing stations with indication of their species composition (percentages in number).

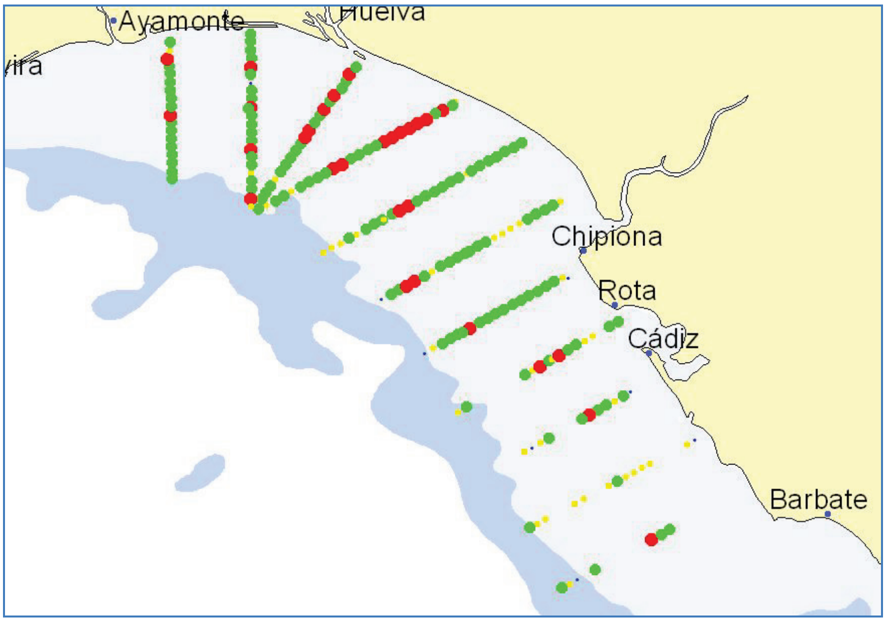


Figure 3. *ECOCÁDIZ-RECLUTAS 1112* survey. Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the pelagic fish species assemblage.

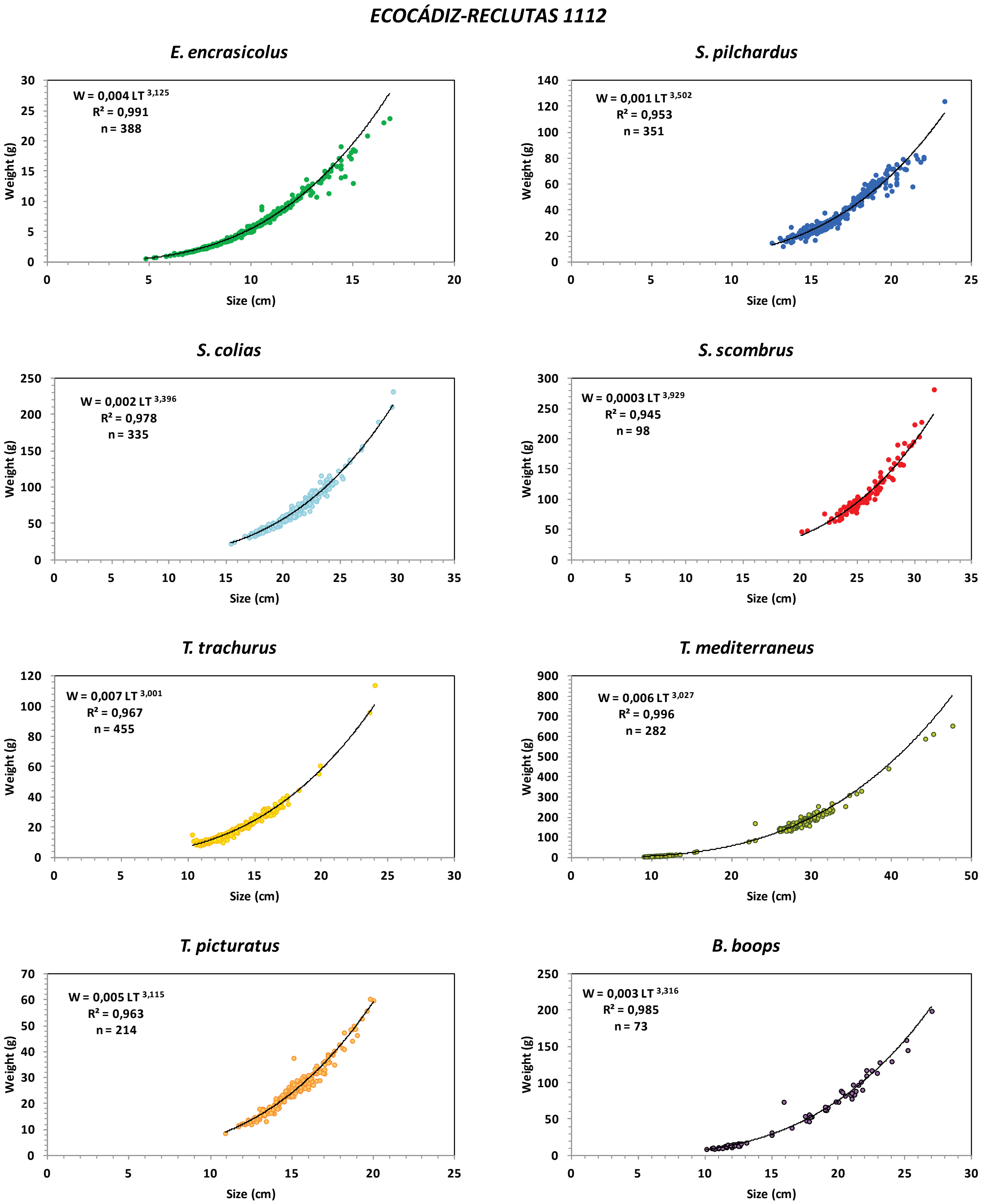


Figure 4. *ECOCÁDIZ-RECLUTAS 1112* survey. Size-weight relationships of the assessed species.

***ECOCÁDIZ-RECLUTAS 1112*: Anchovy (*E. encrasicolus*)**

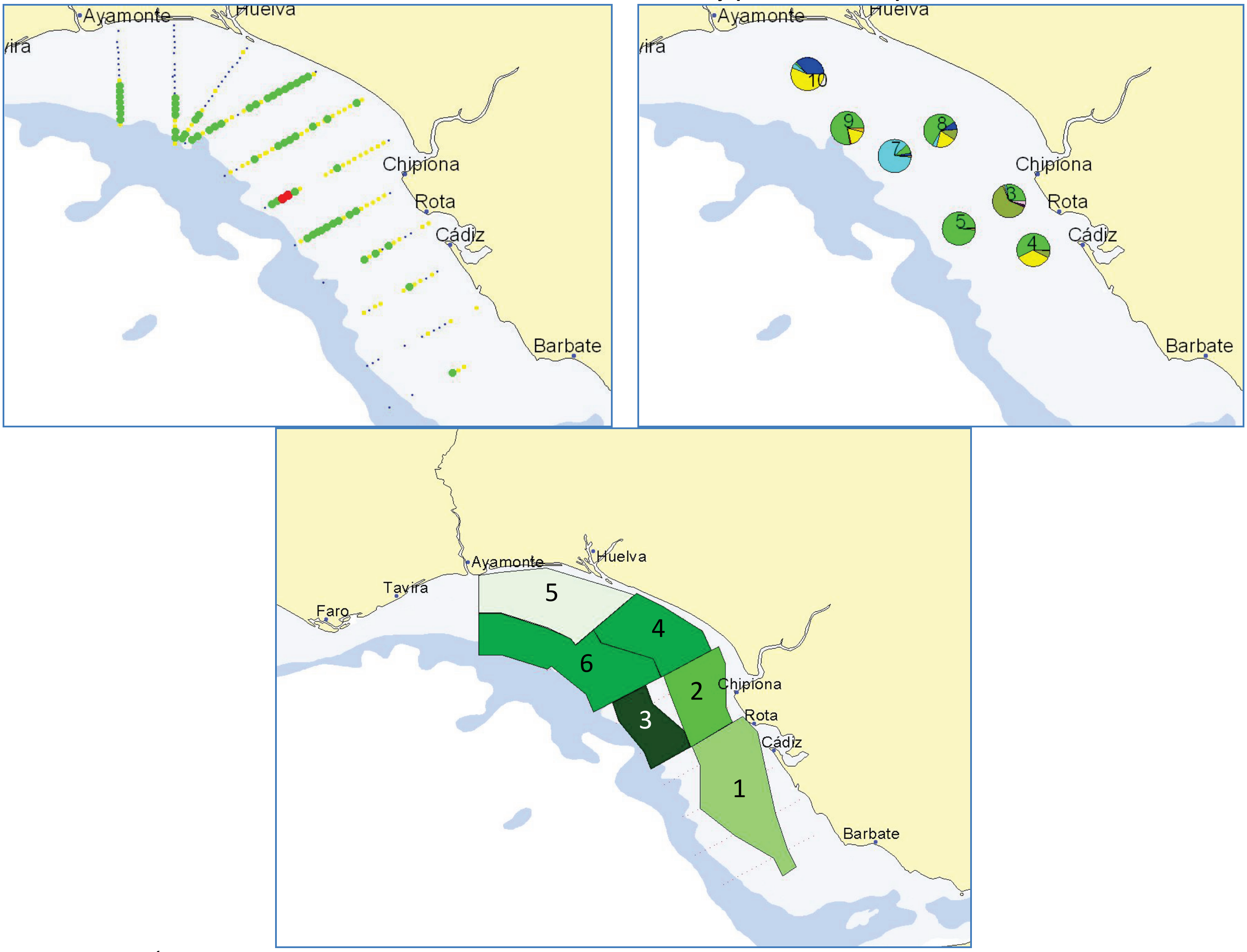


Figure 5. *ECOCÁDIZ-RECLUTAS 1112* survey. Anchovy (*Engraulis encrasicolus*). Top left: Distribution of the backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Top right: valid fishing hauls for the species (more than 30 individuals showing a normal distribution). Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

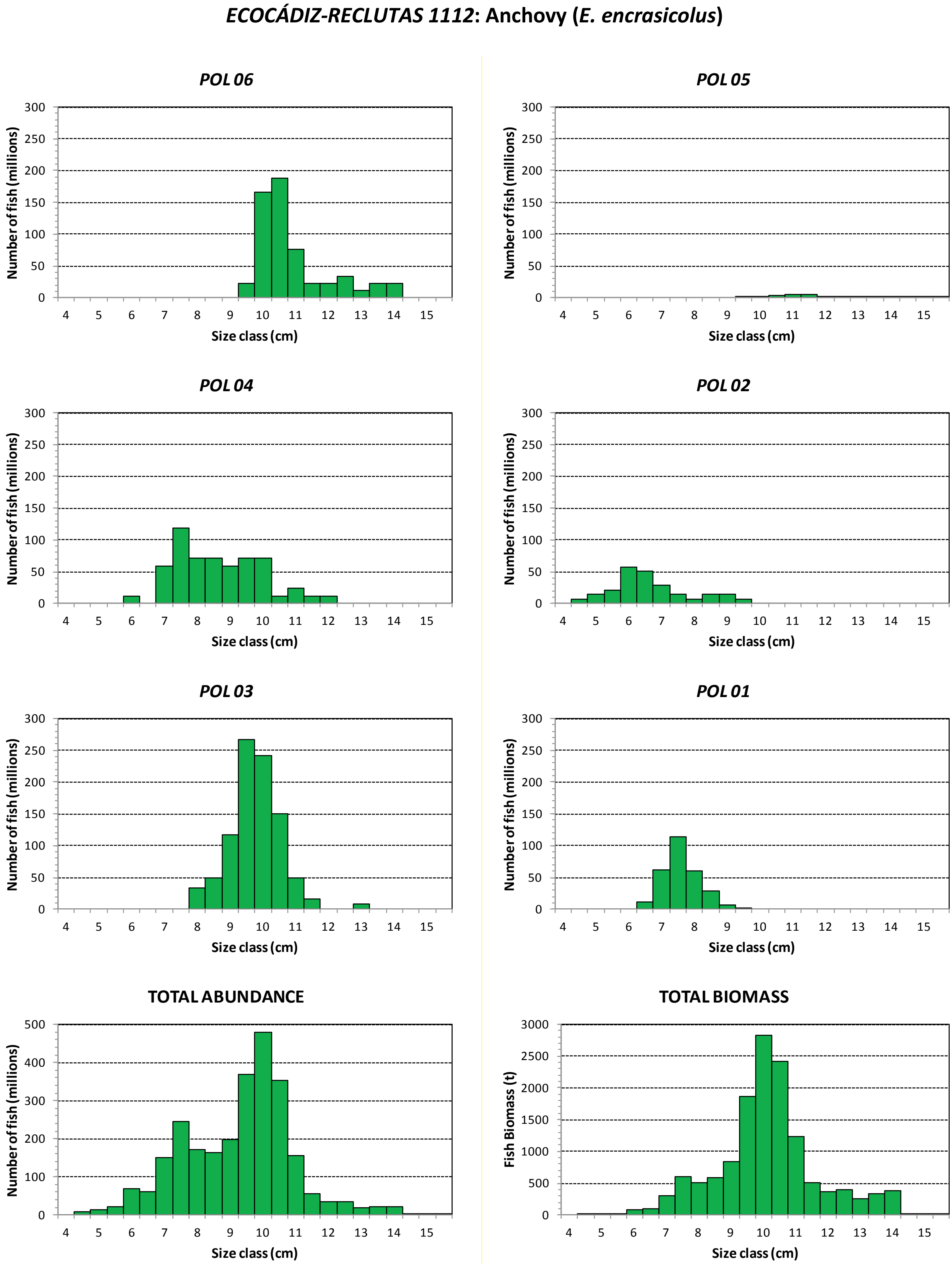


Figure 6. *ECOCÁDIZ-RECLUTAS 1112* survey. Anchovy (*E. encrasicolus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in Figure 5) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

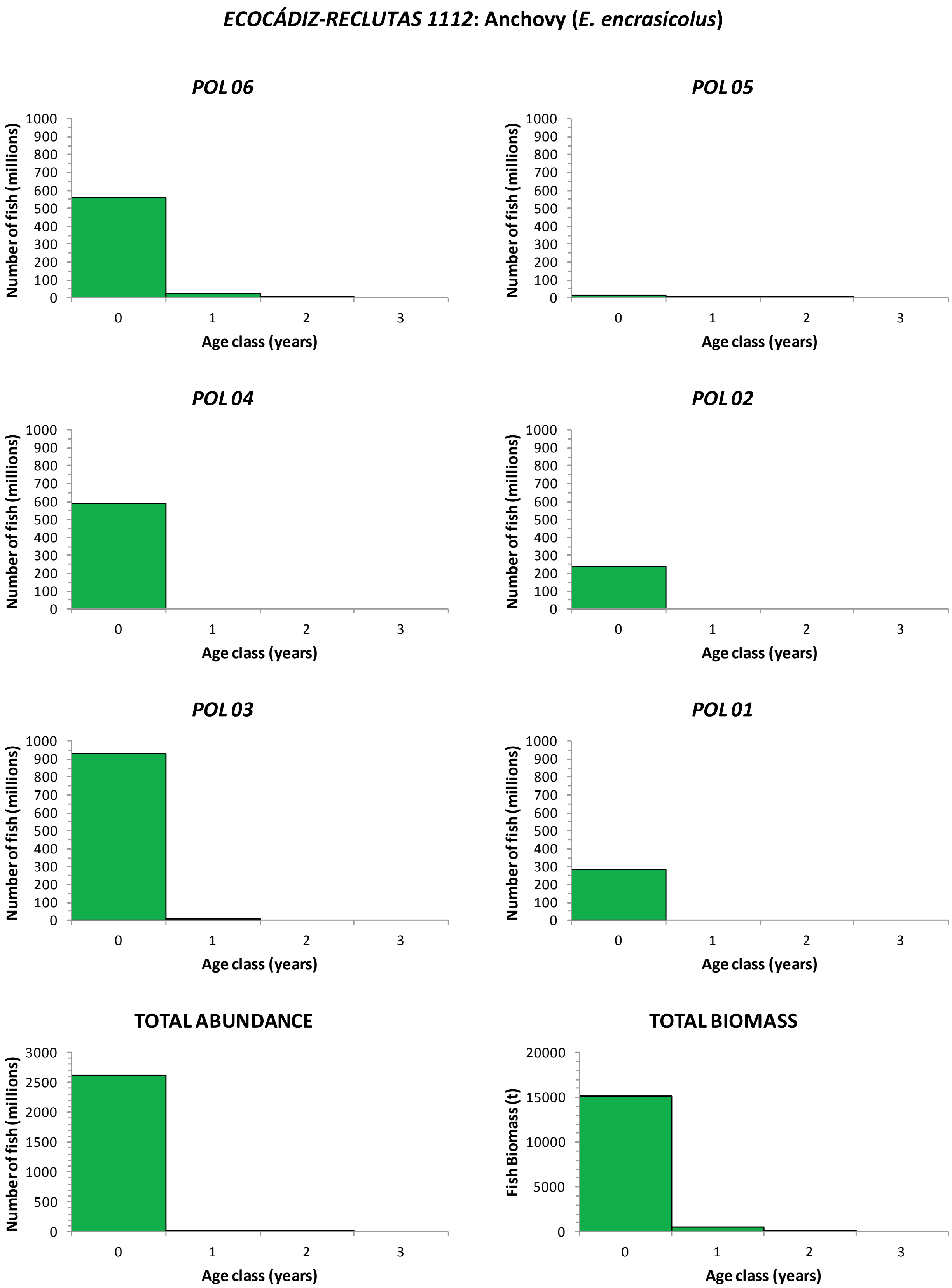


Figure 7. *ECOCÁDIZ-RECLUTAS 1112* survey. Anchovy (*E. encrasicolus*). Estimated abundance (number of fish in millions) by age group by homogeneous stratum (POL01-POLn, numeration as in Figure 5) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by age class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

***ECOCÁDIZ-RECLUTAS 1112*: Sardine (*S. pilchardus*)**

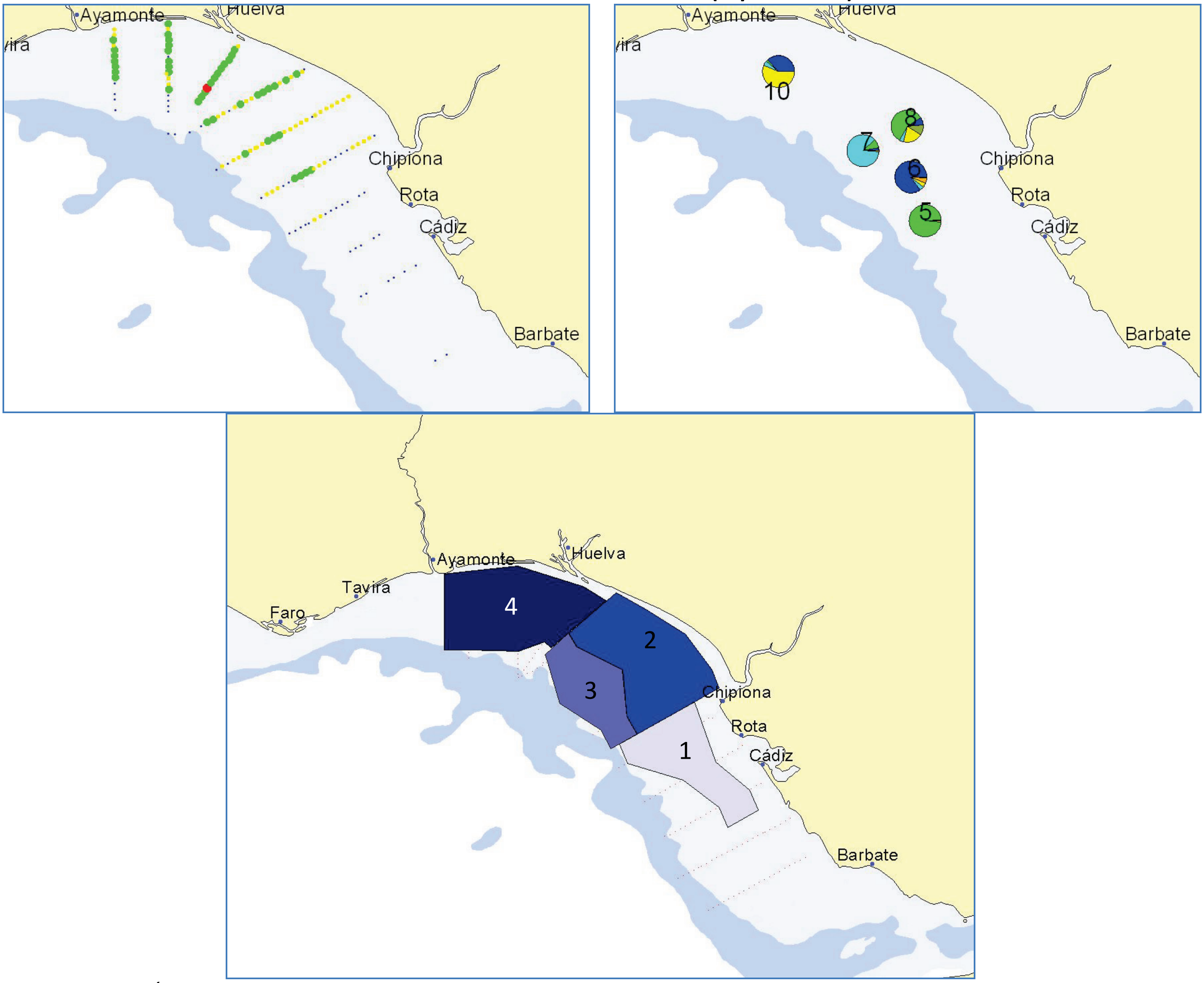


Figure 8. *ECOCÁDIZ-RECLUTAS 1112* survey. Sardine (*Sardina pilchardus*). Top left: Distribution of the backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Top right: valid fishing hauls for the species (more than 30 individuals showing a normal distribution). Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

ECOCÁDIZ-RECLUTAS 1112: Sardine (*S. pilchardus*)

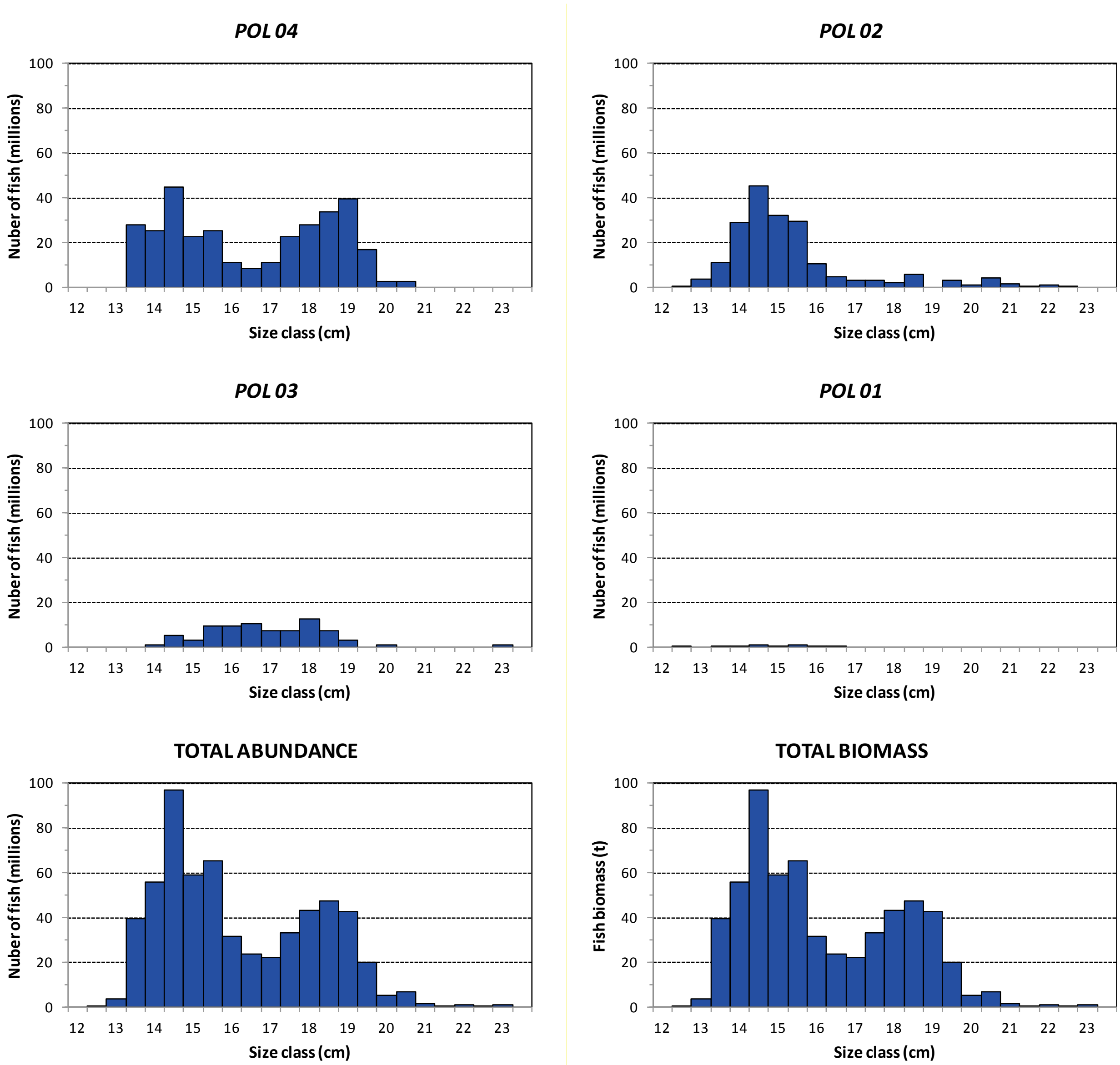


Figure 9. *ECOCÁDIZ-RECLUTAS 1112* survey. Sardine (*S. pilchardus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in Figure 8) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

***ECOCÁDIZ-RECLUTAS 1112*: Chub mackerel (*S. colias*)**

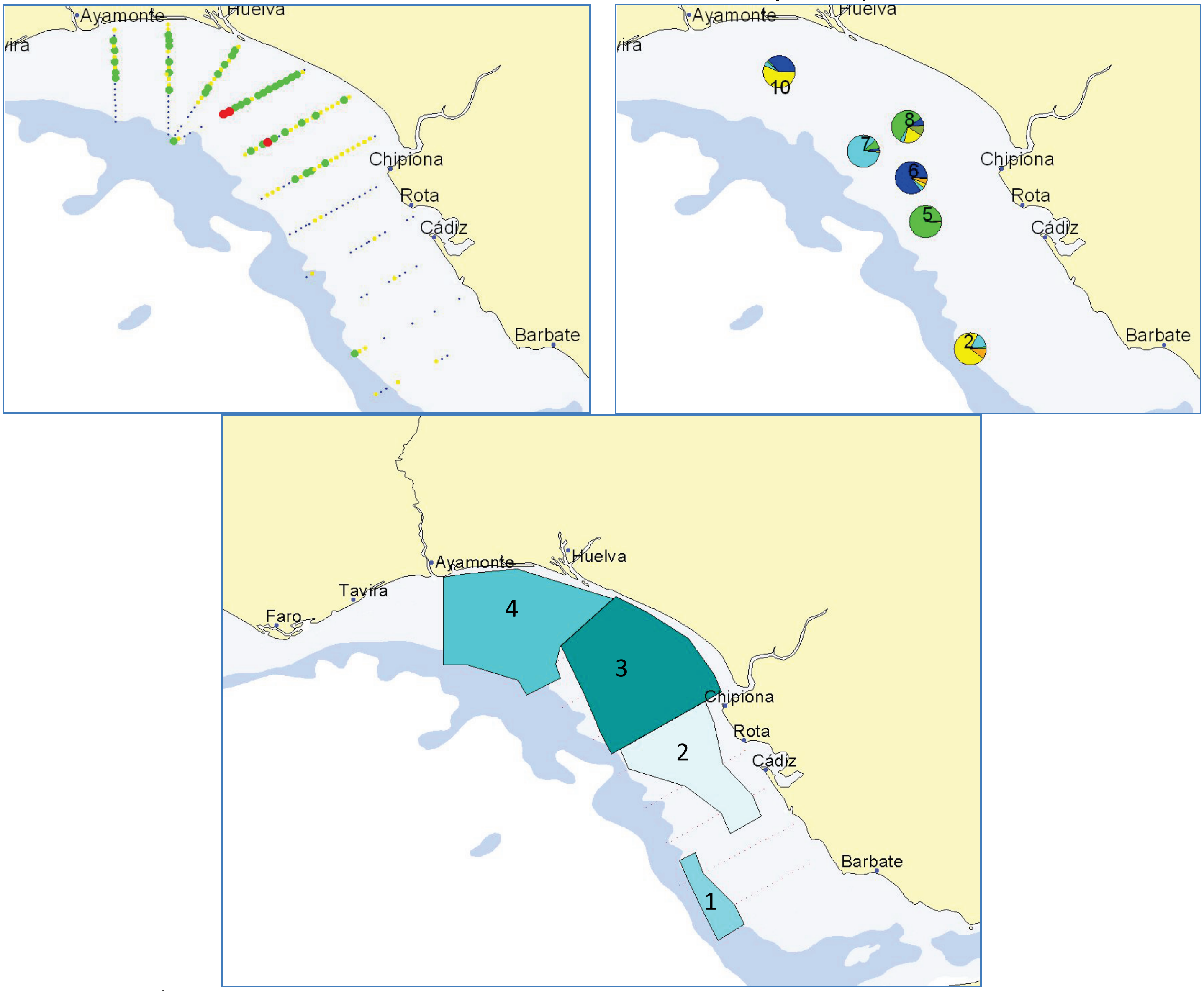


Figure 10. *ECOCÁDIZ-RECLUTAS 1112* survey. Chub mackerel (*Scomber colias*). Top left: Distribution of the backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Top right: valid fishing hauls for the species (more than 30 individuals showing a normal distribution). Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

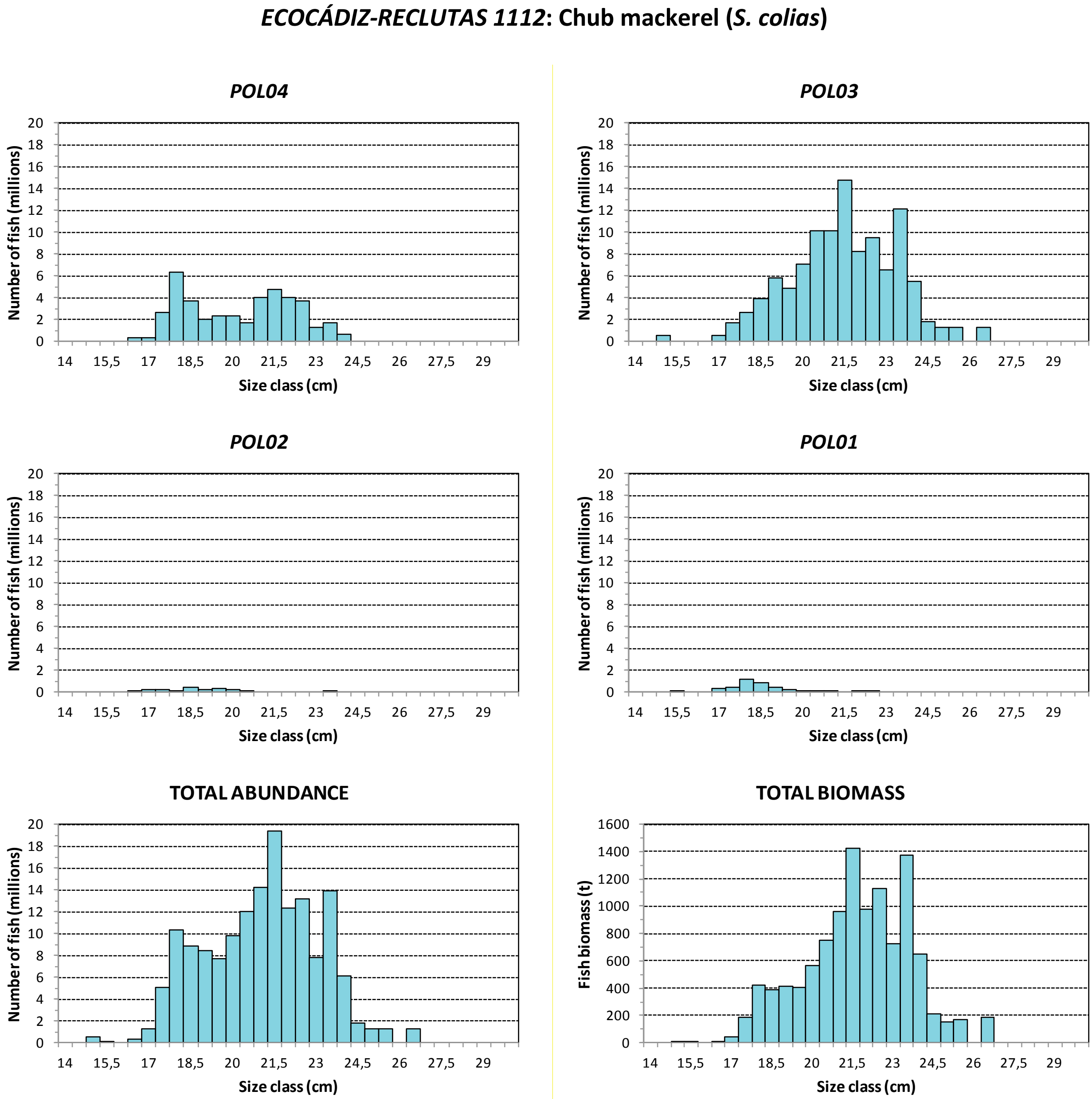


Figure 11. *ECOCÁDIZ-RECLUTAS 1112* survey. Chub mackerel (*S. colias*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in Figure 10) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

***ECOCÁDIZ-RECLUTAS 1112*: Mackerel (*S. scombrus*)**

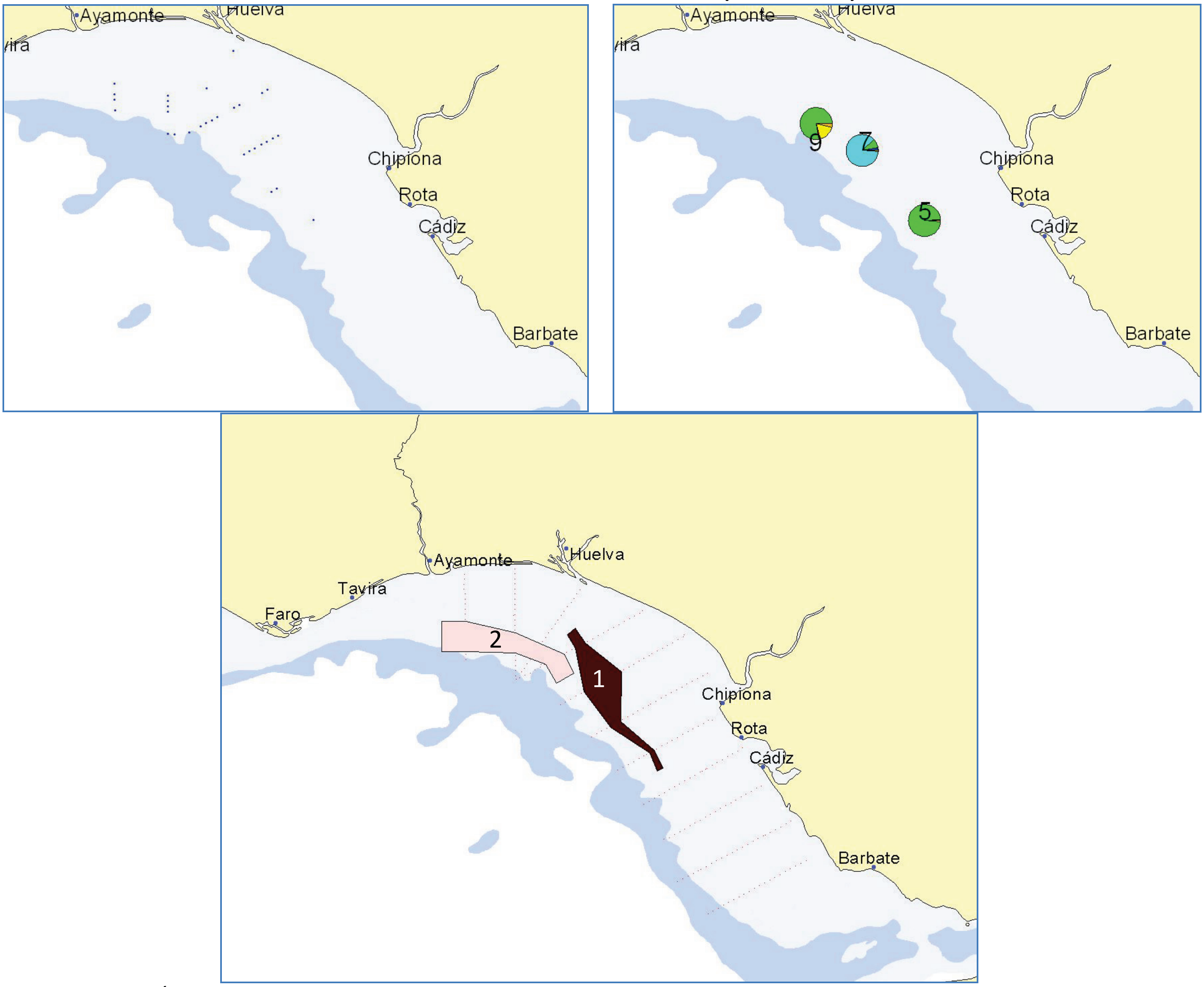


Figure 12. *ECOCÁDIZ-RECLUTAS 1112* survey. Mackerel (*Scomber scombrus*). Top left: Distribution of the backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Top right: valid fishing hauls for the species (more than 30 individuals showing a normal distribution). Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

ECOCÁDIZ-RECLUTAS 1112: Mackerel (*S. scombrus*)

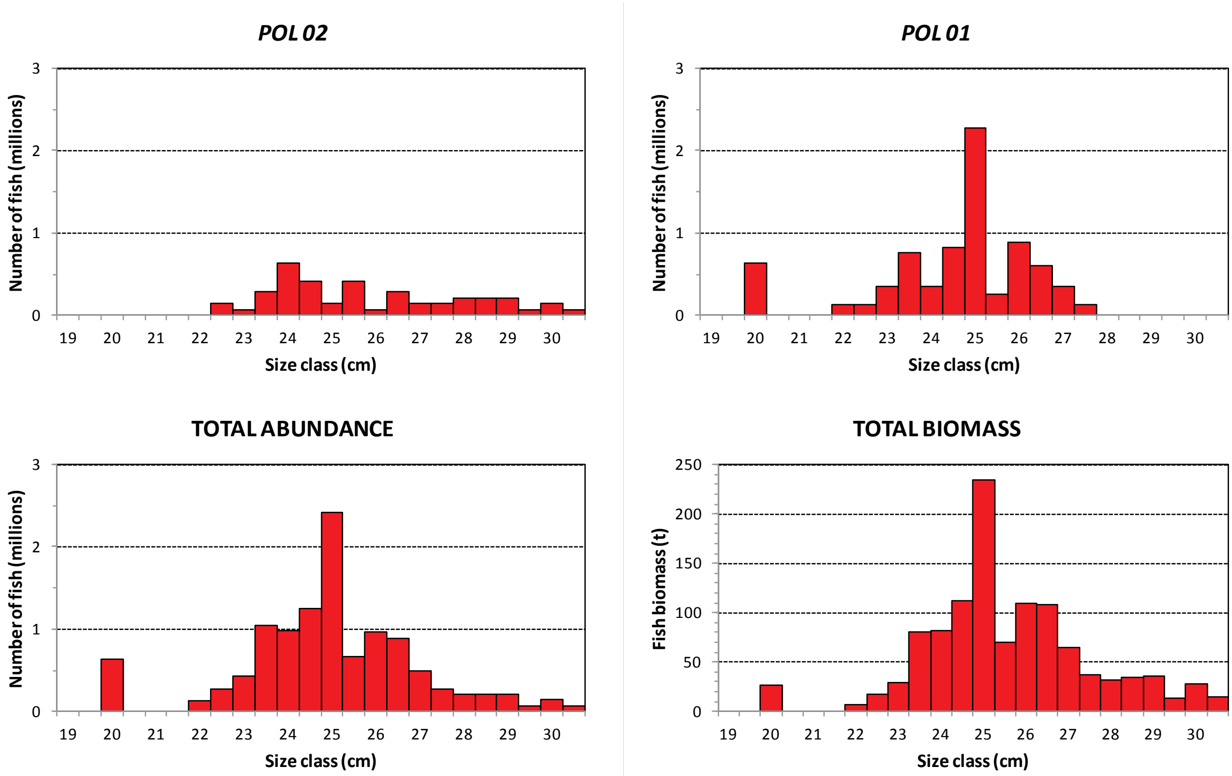


Figure 13. *ECOCÁDIZ-RECLUTAS 1112* survey. Mackerel (*Scomber scombrus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in Figure 12) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

***ECOCÁDIZ-RECLUTAS 1112*: Horse mackerel (*T. trachurus*)**

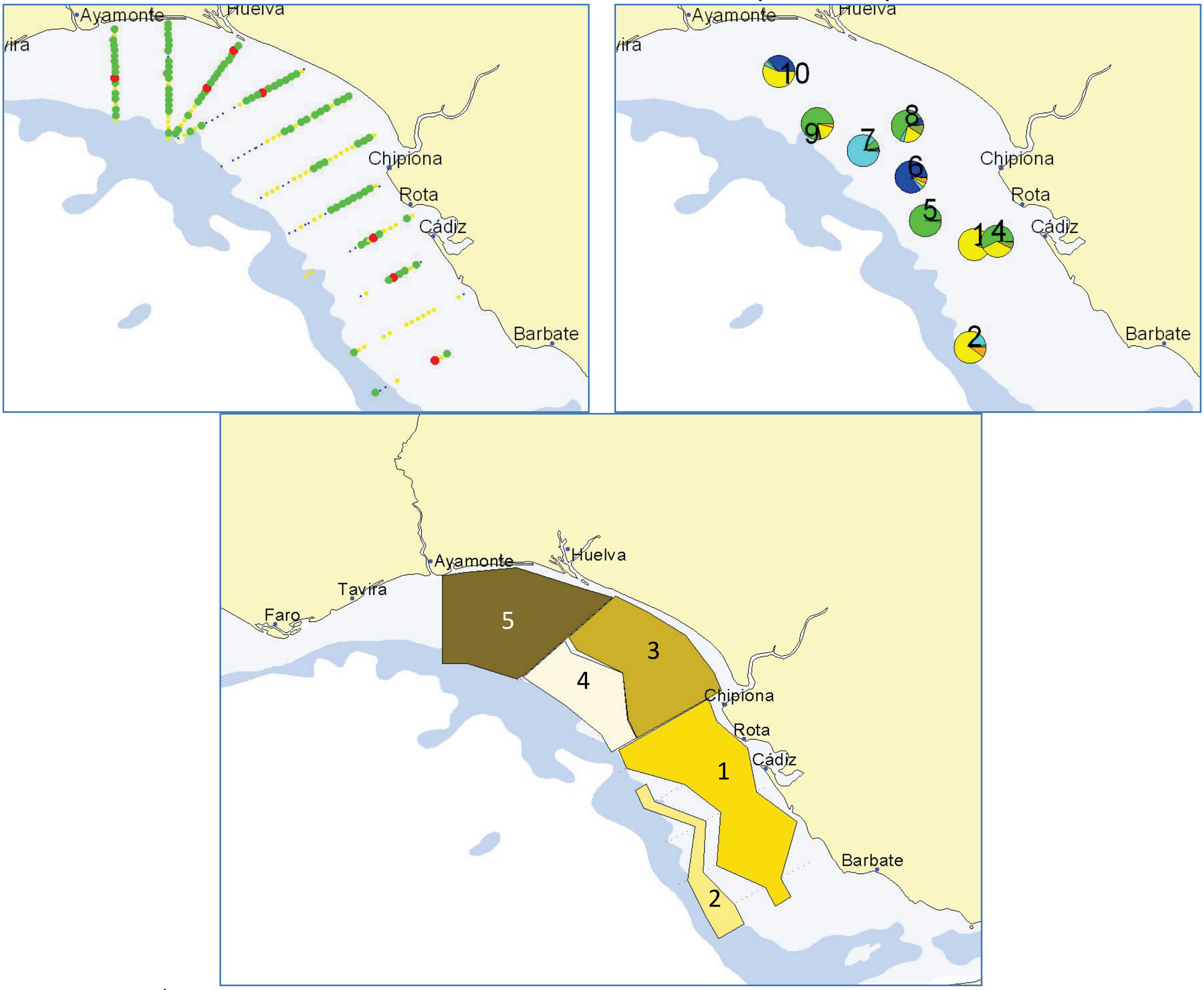


Figure 14. *ECOCÁDIZ-RECLUTAS 1112* survey. Horse-mackerel (*Trachurus trachurus*). Top left: Distribution of the backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Top right: valid fishing hauls for the species (more than 30 individuals showing a normal distribution). Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

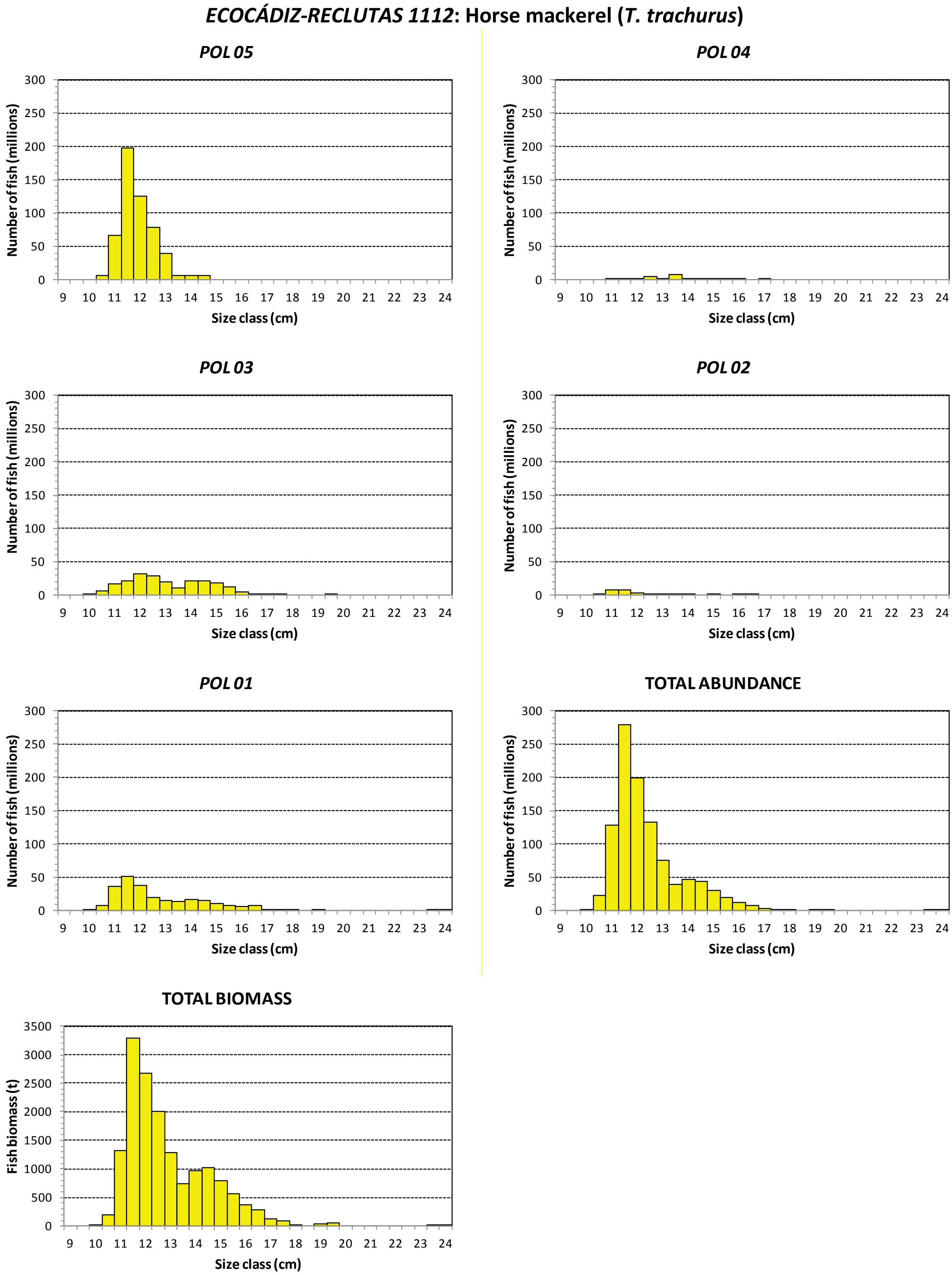


Figure 15. *ECOCÁDIZ-RECLUTAS 1112* survey. Horse-mackerel (*Trachurus trachurus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in Figure 14) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

***ECOCÁDIZ-RECLUTAS 1112*: Mediterranean horse mackerel (*T. mediterraneus*)**

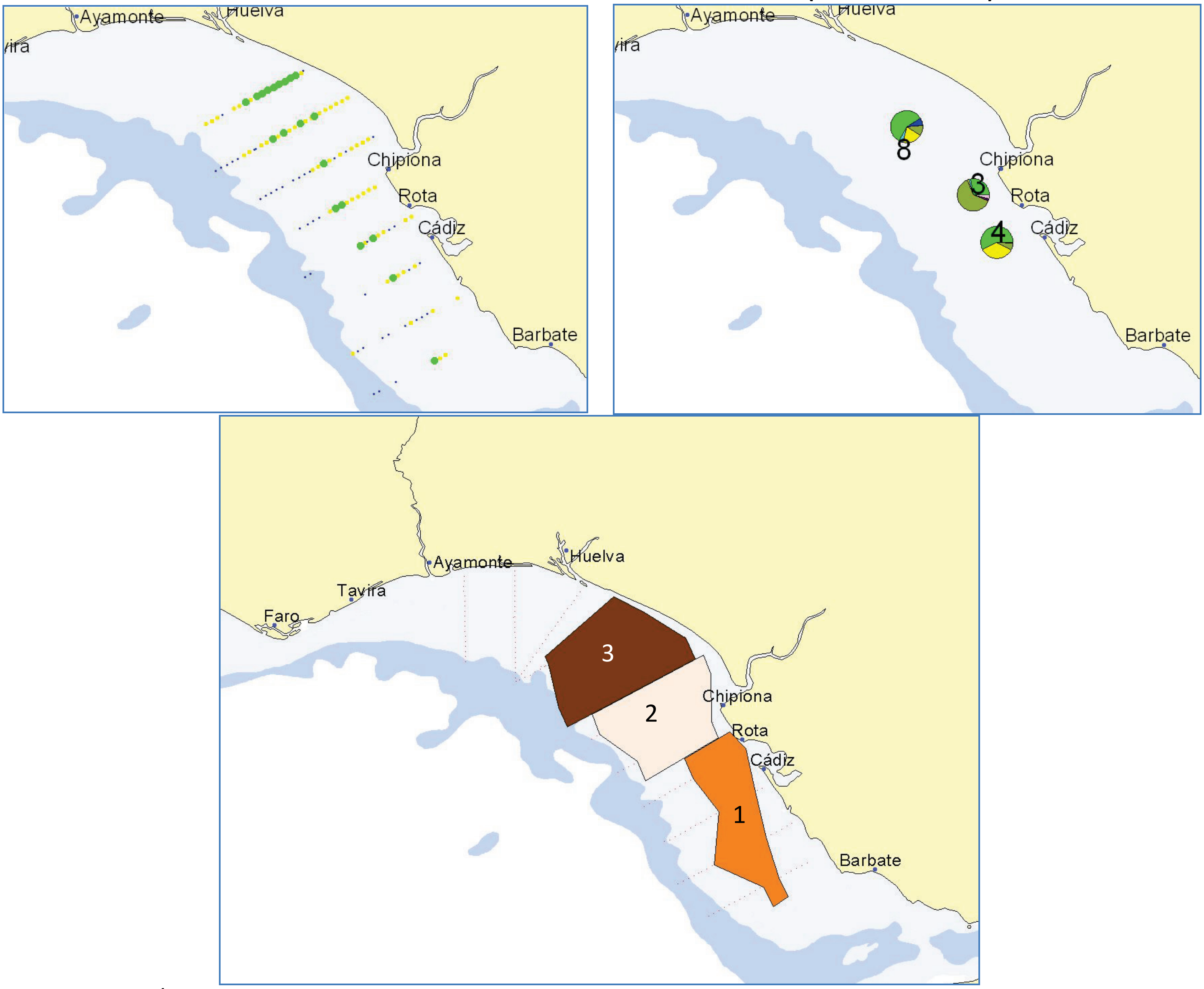


Figure 16. *ECOCÁDIZ-RECLUTAS 1112* survey. Mediterranean horse-mackerel (*Trachurus mediterraneus*). Top left: Distribution of the backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Top right: valid fishing hauls for the species (more than 30 individuals showing a normal distribution). Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

ECOCÁDIZ-RECLUTAS 1112: Mediterranean horse-mackerel (*Trachurus mediterraneus*)

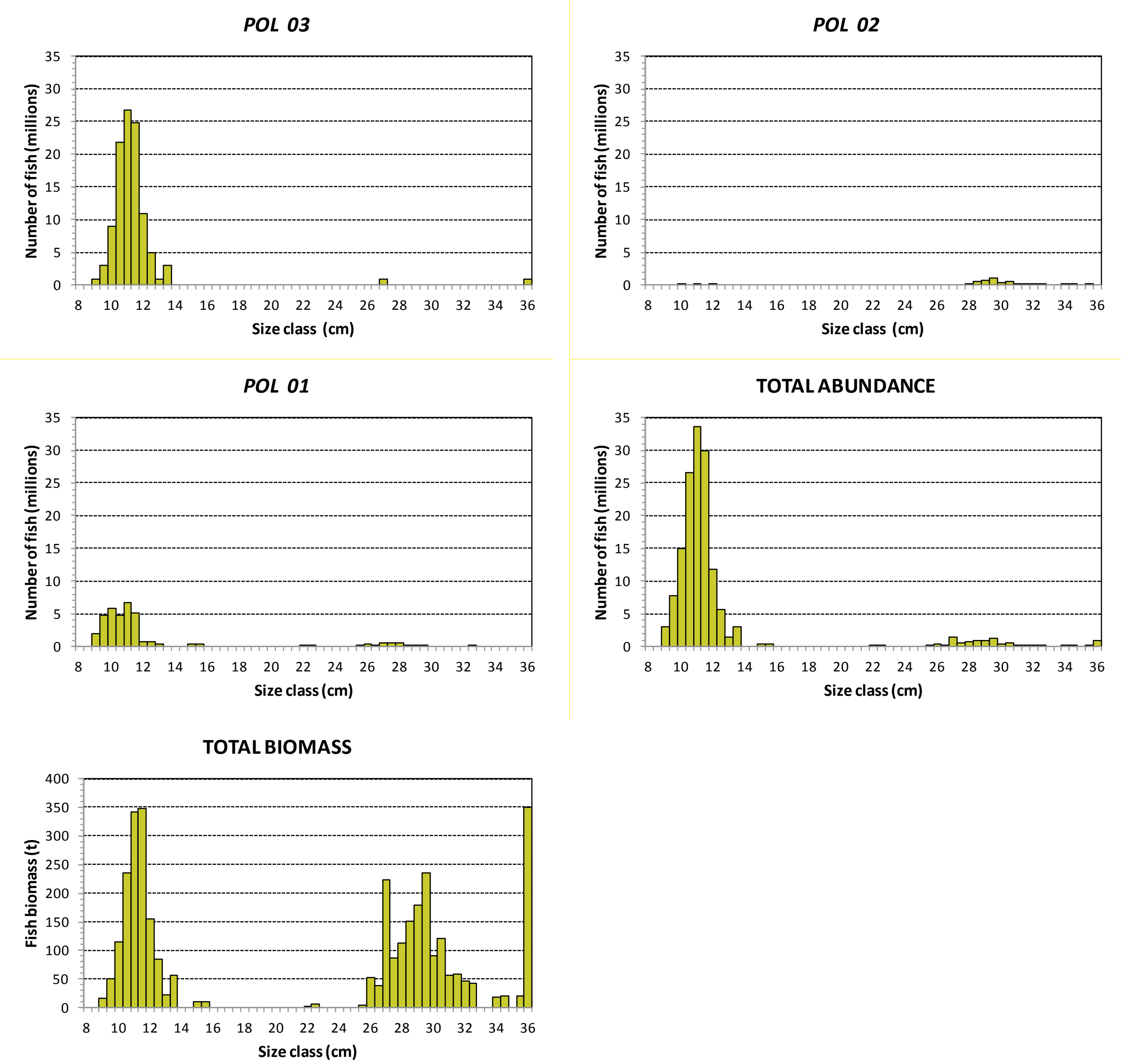


Figure 17. *ECOCÁDIZ-RECLUTAS 1112* survey. Mediterranean horse-mackerel (*Trachurus mediterraneus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in Figure 16) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

ECOCÁDIZ-RECLUTAS 1112: Blue jack mackerel (_T. picturatus_)

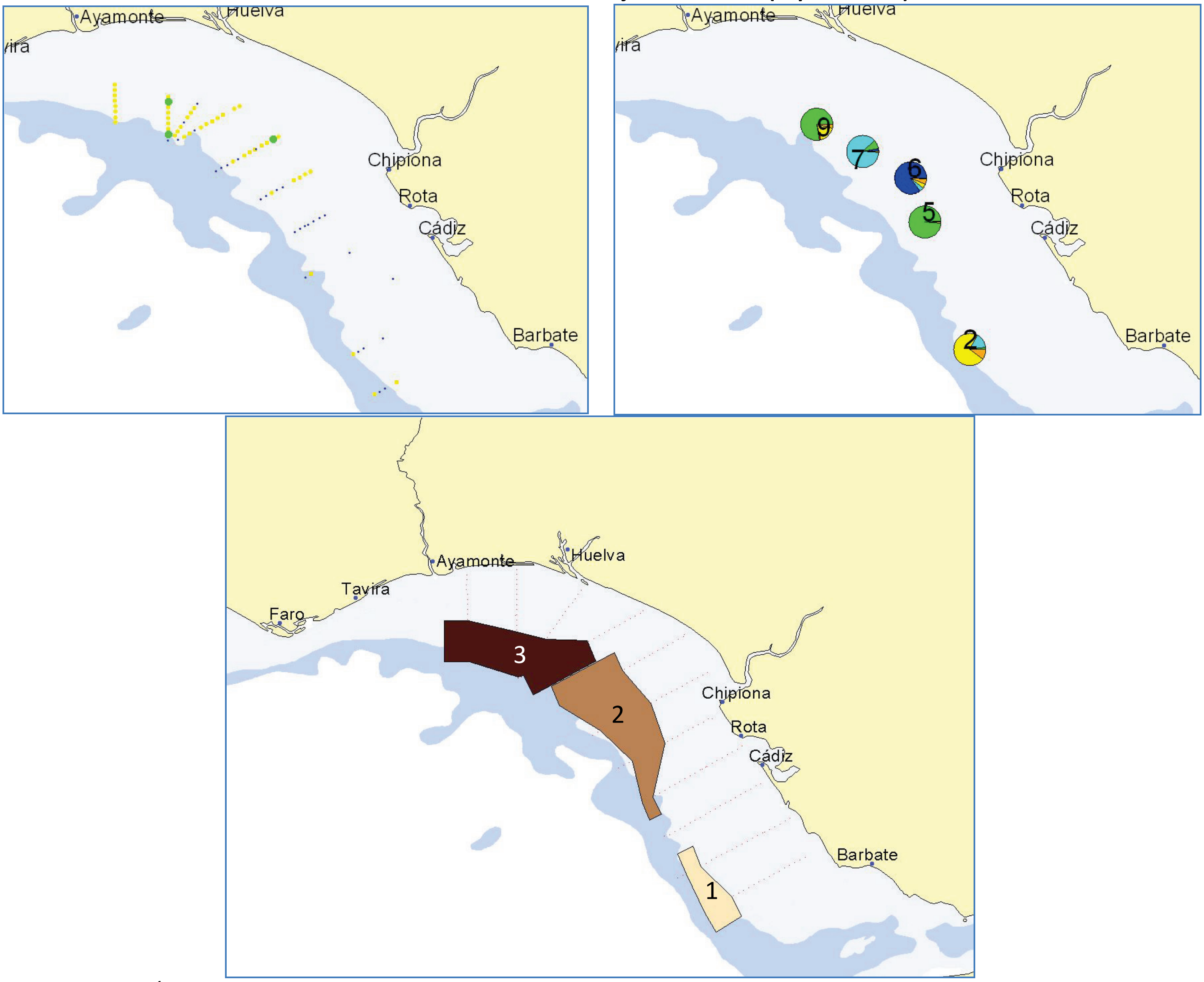


Figure 18. _ECOCÁDIZ-RECLUTAS 1112_ survey. Blue jack mackerel (_Trachurus picturatus_). Top left: Distribution of the backscattering energy (Nautical area scattering coefficient, _NASC_, in m^2 nmi^{-2}) attributed to the species. Top right: valid fishing hauls for the species (more than 30 individuals showing a normal distribution). Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

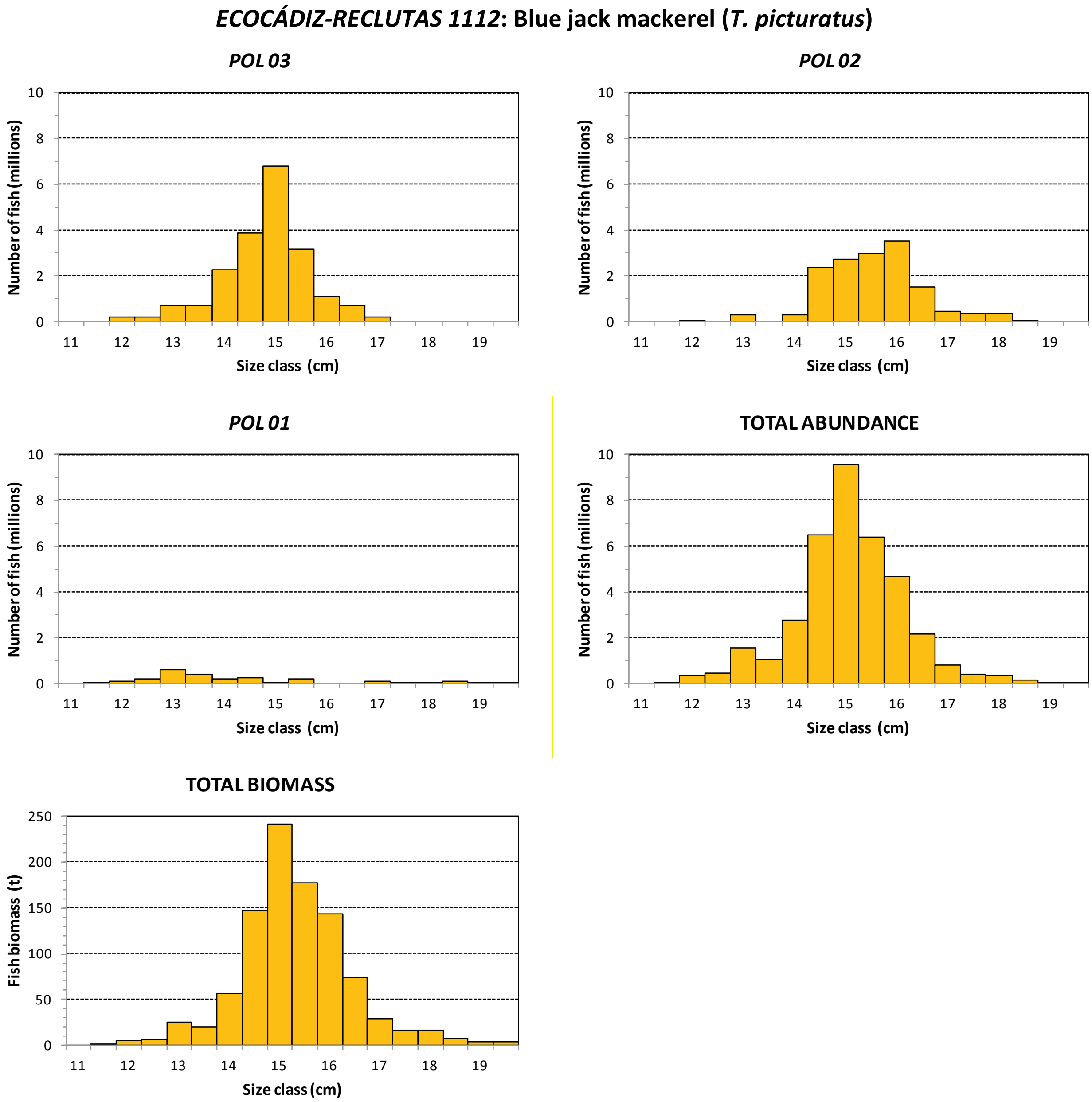


Figure 19. *ECOCÁDIZ-RECLUTAS 1112* survey. Blue jack mackerel (*Trachurus picturatus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in Figure 18) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

***ECOCÁDIZ-RECLUTAS 1112*: Bogue (*B. boops*)**

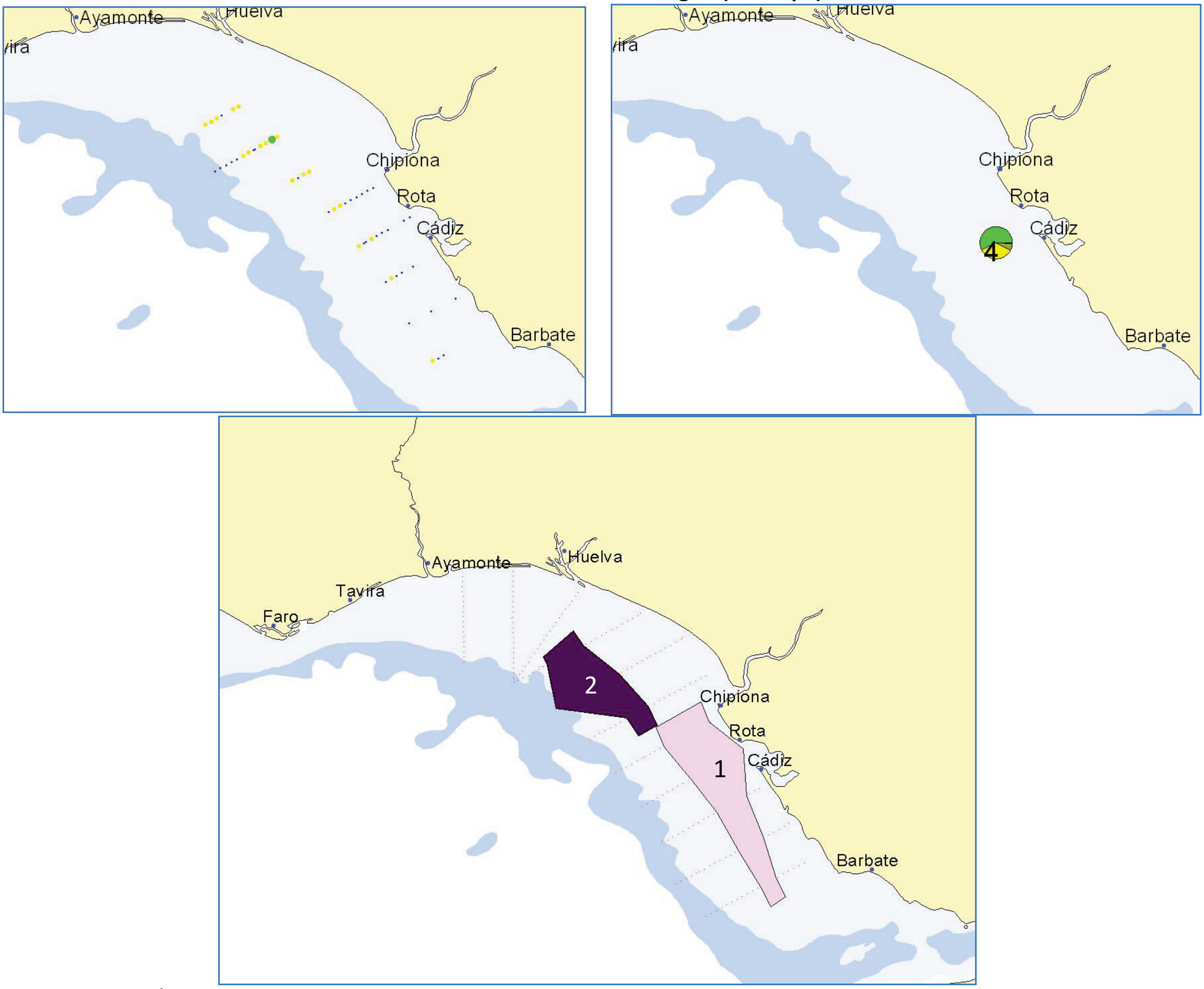


Figure 20. *ECOCÁDIZ-RECLUTAS 1112* survey. Bogue (*B. boops*). Top left: Distribution of the backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Top right: valid fishing hauls for the species (more than 30 individuals showing a normal distribution). Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

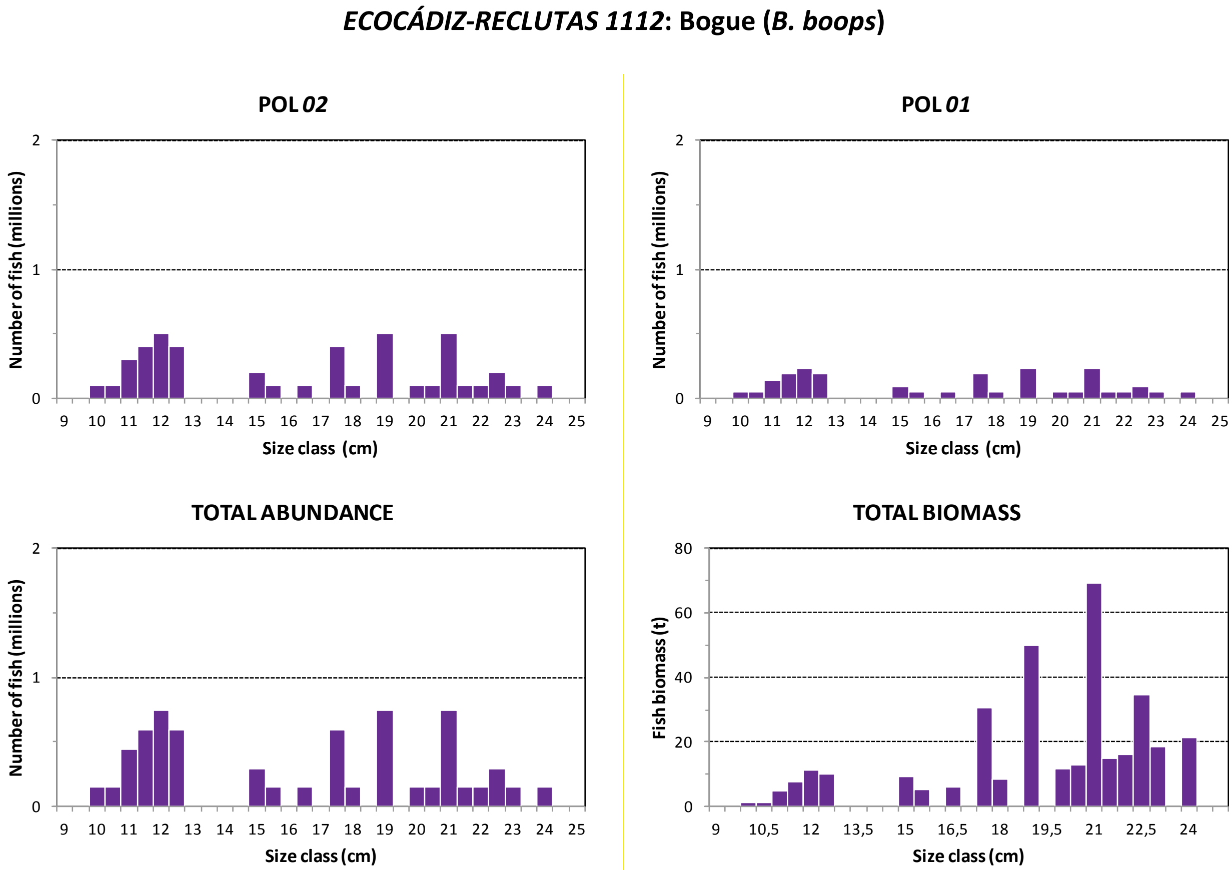


Figure 21. *ECOCÁDIZ-RECLUTAS 1112* survey. Bogue (*B. boops*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in Figure 20) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

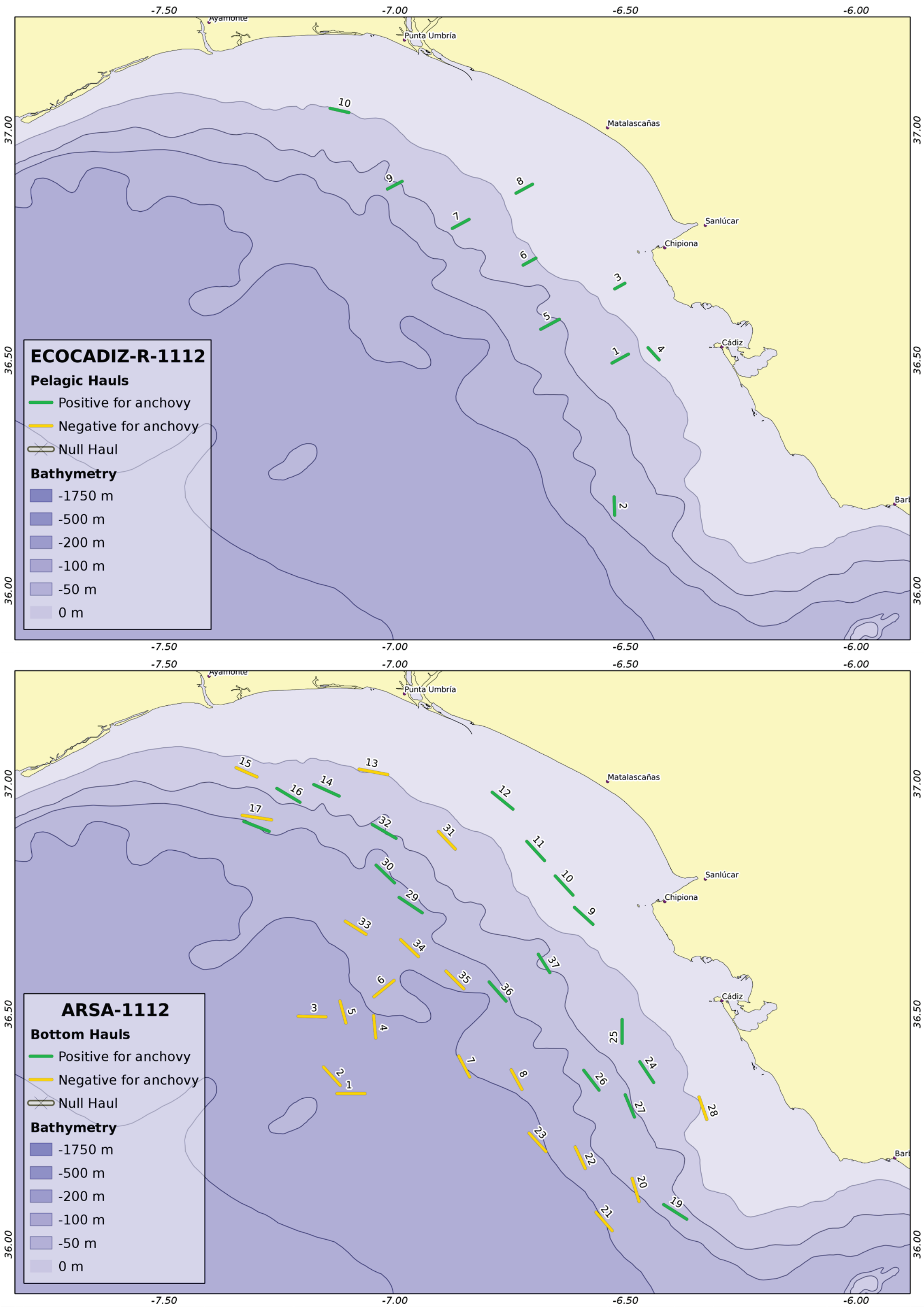


Figure 22. *ECOCÁDIZ-RECLUTAS 1112* survey. Comparison of results obtained from fishing stations carried out during the present survey (11th - 29th November, top) with those ones carried out during the *ARSA 1112* ground-fish survey (02nd – 23rd November, below). Sampling grids with indication of the location of the trawl hauls differentiated between positive and negative for anchovy.

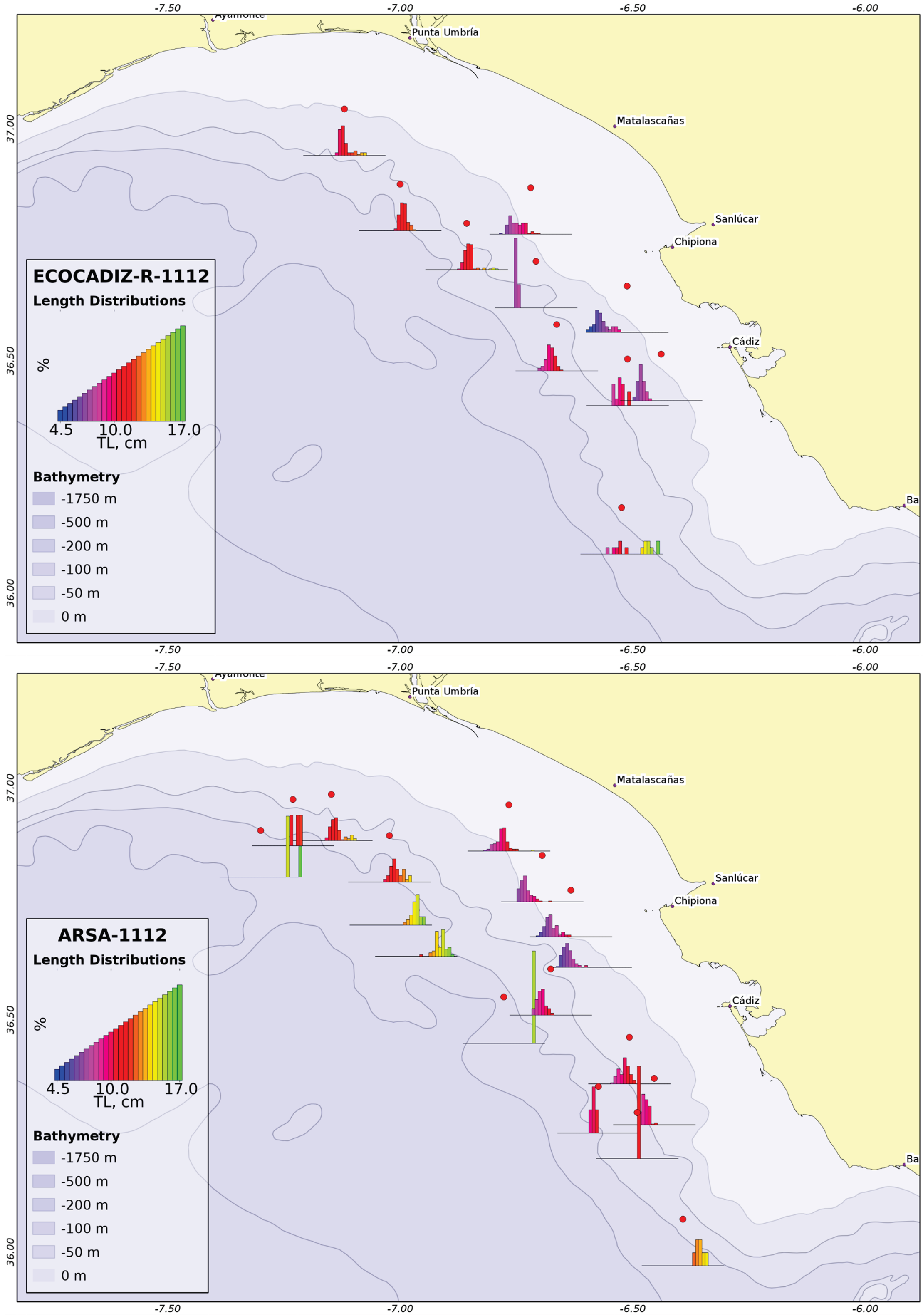


Figure 22. *ECOCÁDIZ-RECLUTAS 1112* survey (cont'd.). Anchovy length frequency distributions by fishing station.

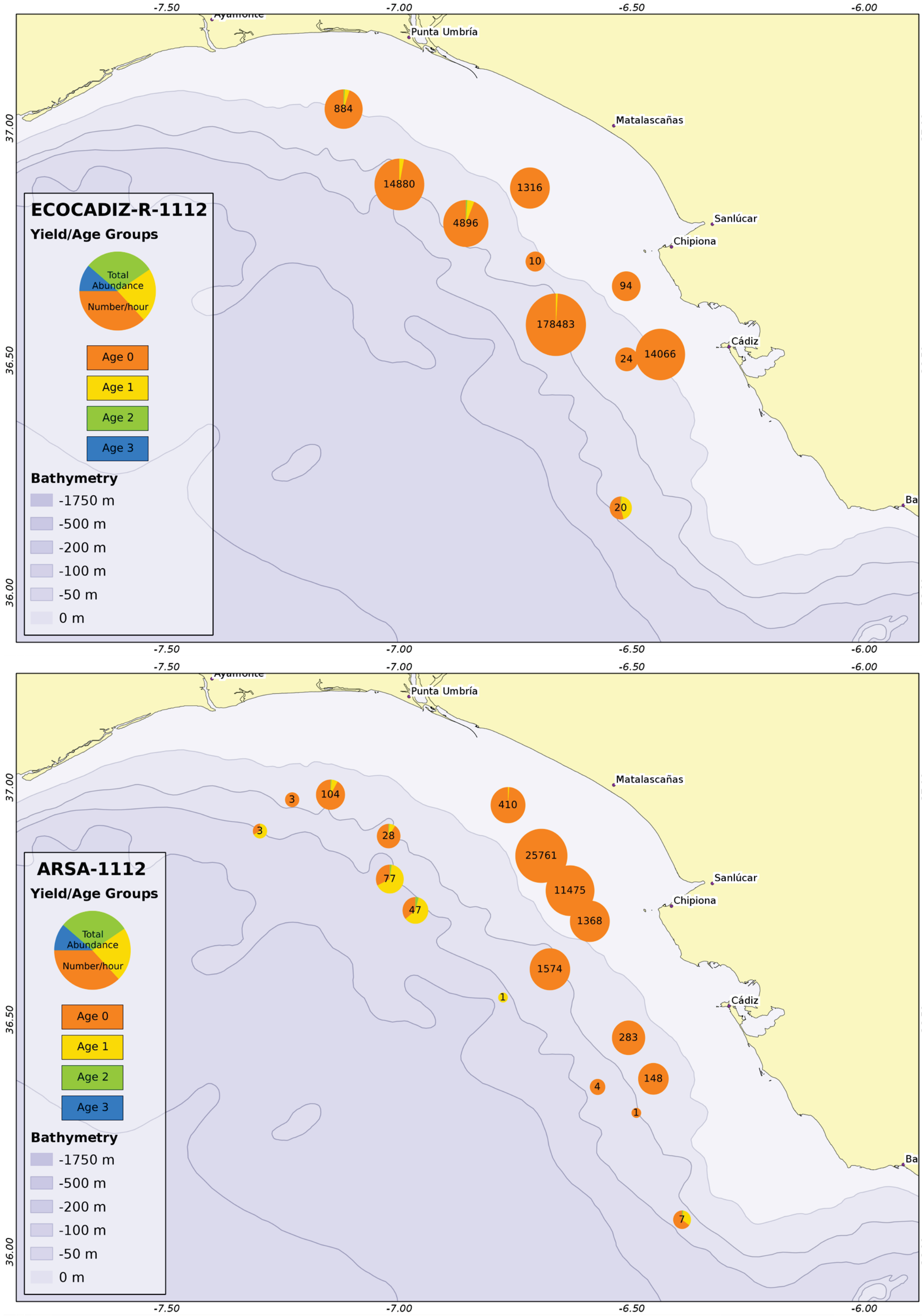


Figure 22. *ECOCÁDIZ-RECLUTAS 1112* survey (cont'd.). Anchovy age composition (% in numbers by trawling hour) by fishing station. Circle size proportional to the yield in numbers. Inserted numbers indicate estimated total numbers by trawling hour.

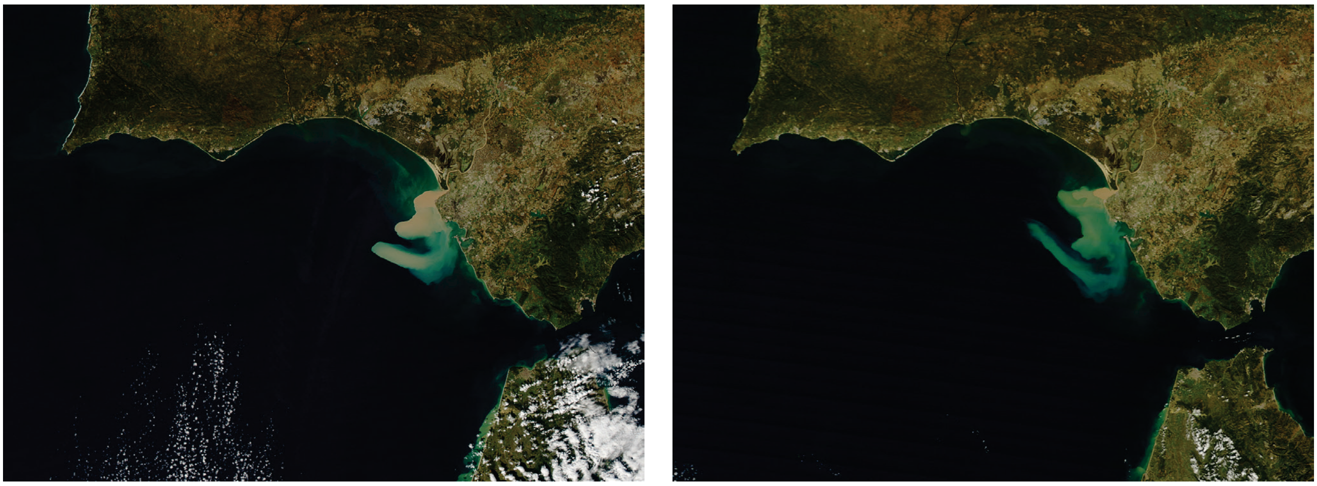


Figure 23. *ECOCÁDIZ-RECLUTAS 1112* survey. Spatial distribution of the plume of continental runoffs from the Guadalquivir River recorded by the MODIS spectroradiometer from the *Aqua* and *Terra* NASA's satellites during the 12nd (left) and 13rd November (right) (natural color).

Working document to ICES WGHANSA, 21-26 June 2013, Bilbao (Spain)

Some pending issues from WKPELA on the assessment of Bay of Biscay anchovy

by

L. Ibaibarriaga and A. Uriarte

Abstract

In the ICES Benchmark Workshop on Pelagic Stocks the assessment method (including projections) and appropriate reference points for anchovy in the Bay of Biscay were considered. However some issues were not finalised and remained to be further studied. In this document we try to address some of these items. In particular, we (a) test the sensitivity of the results to different prior distribution of the catchability of the JUVENA surveys, (b) compare the linear and the potential model and (c) do a retrospective analysis of the assessments conducted in December, so that the prediction capacity of the different model options can also be tested.

1. Introduction

In the ICES Benchmark Workshop on Pelagic Stocks (WKPELA; ICES 2013) the assessment method (including projections) and appropriate reference points for anchovy in the Bay of Biscay were considered. The final assessment was based on the CBBM model (Ibaibarriaga et al. 2011) with changes to settings of natural mortality rates. In addition, the DEPM SSB estimate was considered as a relative index, and the JUVENA juvenile acoustic biomass was included as an index of recruitment next year. However WKPELA was unable to decide on the final setting regarding the variances of the observation equations. In the option presented in the stock annex the precision of the observation equations of biomass from the DEPM and acoustic surveys were taken as fixed (not estimated). After the meeting another option was tested where the variances of SSB observation equations from the surveys were split into partly fixed and estimated variances. This alternative option was added as an annex to the WKPELA report.

The inclusion of the JUVENA juvenile abundance index in the observation equations of the CBBM assessment model was based on a linear relationship between this index and next year recruitment (age 1 biomass at the beginning of the year). This is similar to the observation equation of the DEPM and acoustic biomass indices. The hyper-parameters of the prior distribution of the catchability of the JUVENA survey where taken equal to those of the prior distributions of the catchability of the DEPM and acoustic surveys. The sensitivity of the results to the observation equation relating the JUVENA juvenile abundance index and recruitment next year (linear or potential) and the hyper-parameters of the prior distribution of the parameters defining this relationship were not studied in detail due to the lack of time, and were included in the list of issues to be further studied (ICES 2013).

In this document we test the sensitivity of the results to different prior distribution of the catchability of the JUVENA surveys. Compare the linear and the potential model for both variance cases. In addition, we do a retrospective analysis of the assessments conducted in December, so that the prediction capacity of the different model options can also be tested.

2. Selection of prior distributions related to JUVENA

In WKPELA when including the JUVENA juvenile abundance index a linear model was considered. The prior distribution of the logarithm of the catchability was assumed to be normal with mean 0 and precision (inverse of variance) equal to 2, similarly to the observation equations of BIOMAN and PELGAS biomass indices.

In the results the posterior median of the catchability of the JUVENA survey resulted to be 2.7 for the stock annex proposal with variances fixed and 2.5 for the alternative proposal in annex 3, close to the upper limit of the prior probability interval (Table 1). No sensitivity analysis to the hyper-parameters of the prior distribution of the parameters involved in the JUVENA observation equation was conducted. Therefore, it was not clear whether the prior distribution was fully adequate. In order to check that the prior distribution was not restricting the results, in this document a second prior distribution with higher mean and smaller precision is considered (Table 1).

Alternatively, a third prior distribution with mean 0 and much smaller precision is also tested (Table 1).

The CBBM is applied with the settings described in the stock annex (variances fixed) and in Annex 3 (variances as the sum of fixed and estimated terms) of WKPELA for the three sets of prior distributions given in Table 1.

The three sets of prior distributions and the corresponding posterior distributions of the catchability of JUVENA are shown in Figure 1 and Figure 2 for the two alternative settings regarding the survey variances presented in WKPELA respectively. In both cases the posterior distribution of the catchability of the JUVENA survey gives slightly larger values for the second and third set of priors. However, other parameters such as the posterior time series of recruitment or fishing mortality by semester remain almost unaffected (not shown here), suggesting that the set of priors considered in WKPELA could be too restrictive for the catchability of the JUVENA survey. In what follows the third prior distribution which is the less informative one (wider prior probability intervals) is used for the catchability of the JUVENA survey. This prior distribution would be used regardless the JUVENA index observation model is linear or power (see below).

3. Linear or power model for the JUVENA index

In WKPELA the JUVENA juvenile abundance index was included in the observation equations of the CBBM assessment model based on a linear relationship between this index and next year recruitment. Alternatively, the more general case where there the relationship between the JUVENA index and next year recruitment is potential could be considered, as follows:

$$\log\left(R_{\text{juv}}(y)\right) \sim \text{Normal}\left(\log\left(q_{\text{juv}}\right) + k_{\text{juv}} \log\left(R_y\right), \frac{1}{\psi_{\text{juv}}}\right),$$

where q_{juv}, k_{juv} and ψ_{juv} are respectively the catchability, the power and the precision of the JUVENA surveys that need to be estimated. Notice that when $k_{\text{juv}} = 1$ this is reduces to the linear model.

Here, the CBBM is applied with a power model for the settings described in in the stock annex (variances fixed) and in Annex 3 (variances as the sum of fixed and estimated terms) of WKPELA. The prior distribution of the logarithm of the catchability of the JUVENA surveys $\log\left(q_{\text{juv}}\right)$ is assumed to be normal with mean 0 and precision 0.1 (third prior distribution in Table 1) whereas the prior distribution of the logarithm of the power parameter $\log(k_{\text{juv}})$ is taken as normal with mean 0 and a low precision (set at 0.5).

The comparison of the posterior distributions of recruitments, fishing mortalities in the first and second semesters depending on whether the JUVENA index observation model is linear or power is shown in Figure 3 and Figure 4 for the settings described in stock annex and in Annex 3 respectively. The posterior distributions of the rest parameters estimated are compared in Table 2 and Table 3. In general, regardless the variance settings, the only parameters changing depending on the whether the observation model for the JUVENA index is linear or power are the parameters involved in that model, namely, the catchability, the power and the precision of the JUVENA index observation equation. In the linear model the catchability parameter is above 3, whereas in the power model the catchability decreases to less than 0.05 and the power parameter is estimated to be around 1.5. The results show that the power model fits better to the data available than the linear model because a) the precision parameter is higher for the power model for both variance cases and b) the posterior probability intervals of the power parameter (k_{juv}) does not include the value 1, which is the value corresponding with the linear case.

4. Retrospective analysis: assessment vs. prediction

A retrospective analysis of the assessment conducted in December for different settings depending on the JUVENA index model (linear/power) and the variance settings (as in stock annex or as in Annex 3 in WKPELA) is conducted. This allows to test whether there is a retrospective pattern in the past SSB estimates and to check the prediction capabilities of recruitment when including JUVENA in the assessment.

The retrospective pattern in each year biomass is calculated as the relative change in median biomass with respect to the last assessment conducted in December 2012:

$$\frac{B_y^k - B_y^{2012}}{B_y^{2012}},$$

where B_y^k represents the median biomass of year y of the assessment conducted in year k. These values are shown in Table 4 and in Table 5 for the stock annex and Annex 3 variance settings respectively. For the Annex 3 case (variance fixed + estimated) the last year biomass is almost always corrected upwards between 10 and 30%. These corrections are much lower (less than 10%) in the stock annex case (variances fixed). However, the previous biomasses are mainly corrected downwards, being the correction much larger for the stock annex case (variance fixed), mainly for the assessment conducted before 2008. In general there are almost no differences depending on the observation model for the JUVENA index (linear or power), but the lower average corrections are found for the power model with the same variance settings as the Annex 3 in WKPELA.

Regarding the prediction capacity of recruitment for the different model settings, Figure 5 and Figure 6 compare the recruitment distribution as predicted in the December assessment using only the JUVENA index, as estimated in the December assessment once the latest spring surveys indices and catch data are included and as estimated in the last assessment conducted in December 2012. In all cases the recruitments assessed after the spring surveys are included within the predicted recruitment distribution based only on the JUVENA index. Figure 7 compares the recruitment predictions for different settings showing that the power model provides narrower intervals.

5. Conclusions

- The prior distribution of the catchability of the JUVENA index considered in WKPELA might be too restrictive. The alternative considered in this document with a higher mean and smaller precision seems to be a better candidate, which results valid for both catchability models for JUVENA (linear or power).

- The power model for the JUVENA index observation equation seems to be better than the linear model, as it results in a more precise fitting, with a power parameter different from 1.
- The variance fixed settings lead to lower retrospective corrections in the last year biomasses, but higher corrections in the previous biomasses (specially for the assessments before 2008) in comparison with the variance fixed plus estimated settings.
- The lower average corrections in median biomasses are found for the power model with the same variance settings as the Annex 3 in WKPELA (fixed plus estimated).
- The power model for the observation equation of the JUVENA index leads to narrower probability intervals for the next year recruitment than the linear model. In all cases the recruitments assessed after the spring surveys are included within the predicted recruitment distribution based only on the JUVENA index.

6. References

Ibaibarriaga, L., Fernandez, C., and Uriarte, A. 2011. Gaining information from commercial catch for a Bayesian two-stage biomass dynamic model: application to Bay of Biscay anchovy. ICES J. Mar. Sci. **68**(7): 1435-1446.

ICES. 2013. Report of the Benchmark Workshop on Pelagic Stocks (WKPELA 2013). p. 483.

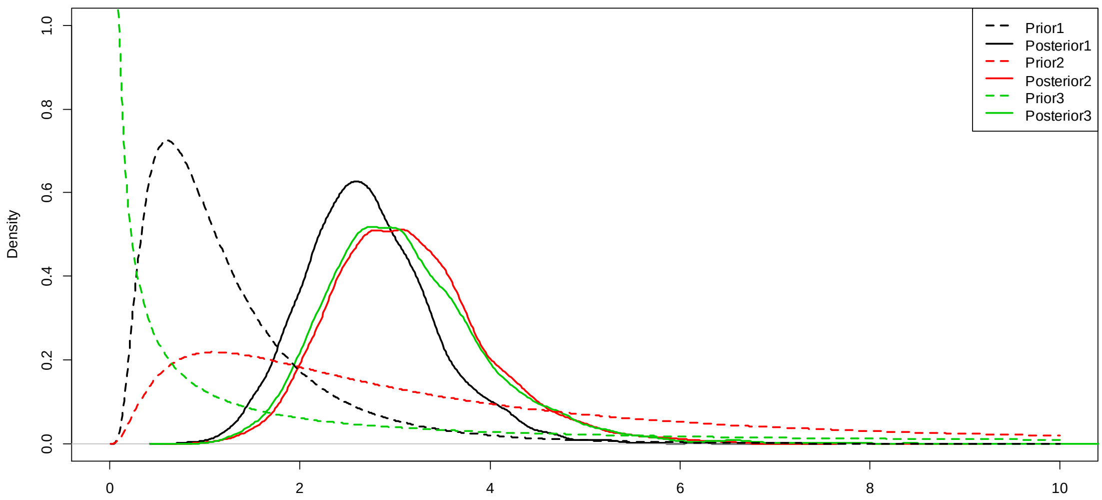


Figure 1: Comparison of the prior (dashed line) and posterior (solid line) distributions for the two sets of prior distributions considered (see line colour). The CBBM was run with the settings specified in the WKPELA stock annex (variances fixed).

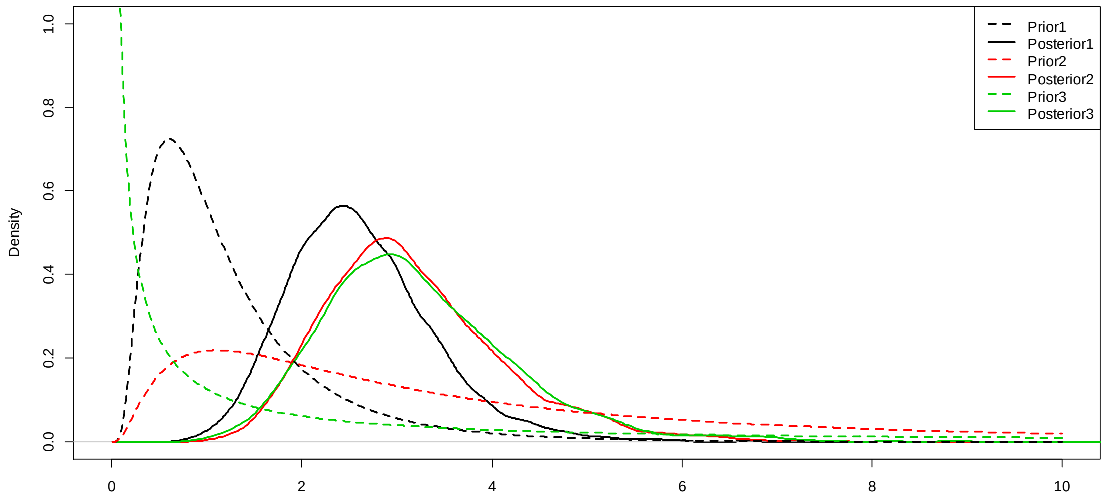


Figure 2: Comparison of the prior (dashed line) and posterior (solid line) distributions for the two sets of prior distributions considered (see line colour). The CBBM was run with the settings specified in the WKPELA Annex 3 (variances as the sum of fixed and estimated effects).

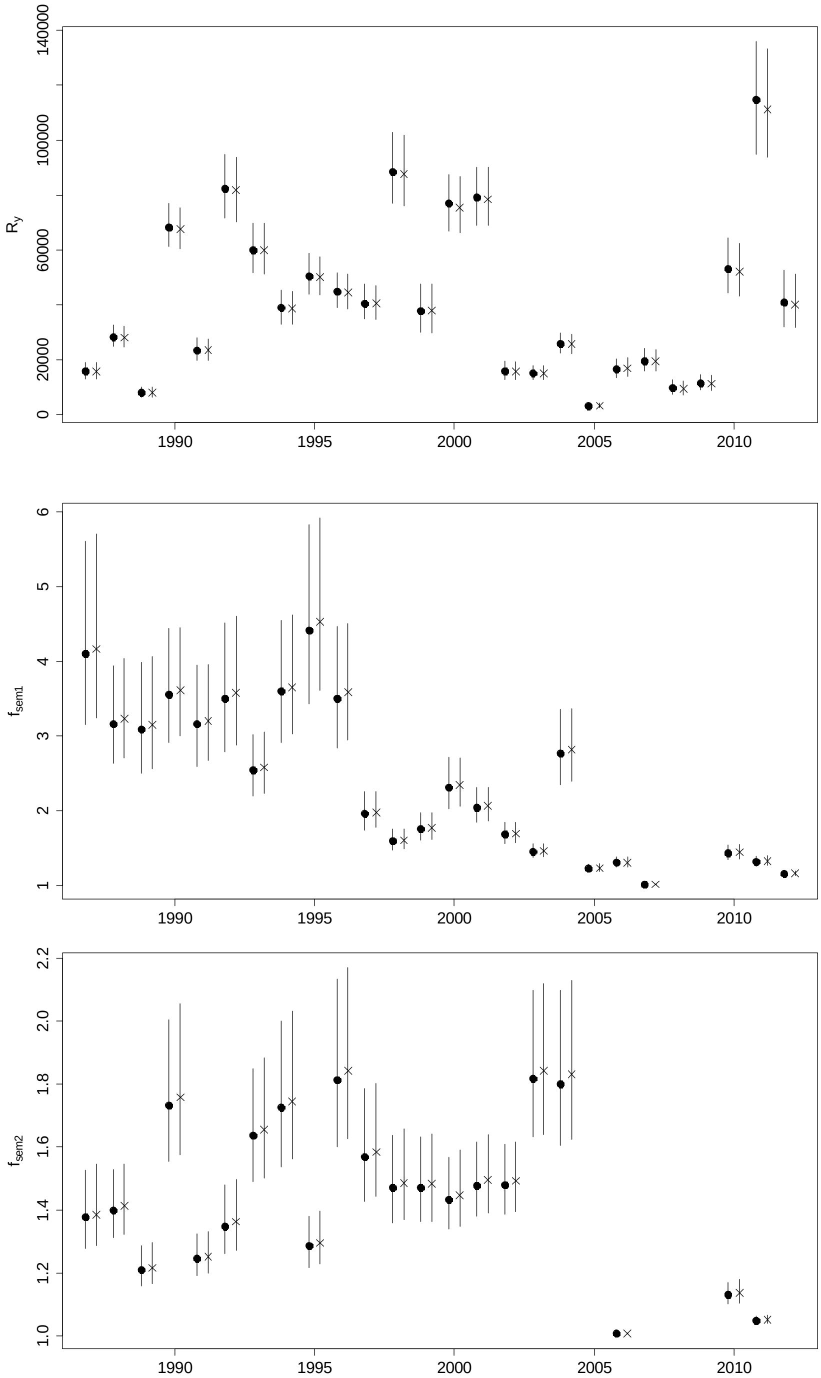


Figure 3: From top to bottom comparison of recruitment and fishing mortalities in the first and in the second semester for the linear (bullet) and the power (cross) model for the JUVENA index. The variance setting is the same as in the stock annex of WKPELA.

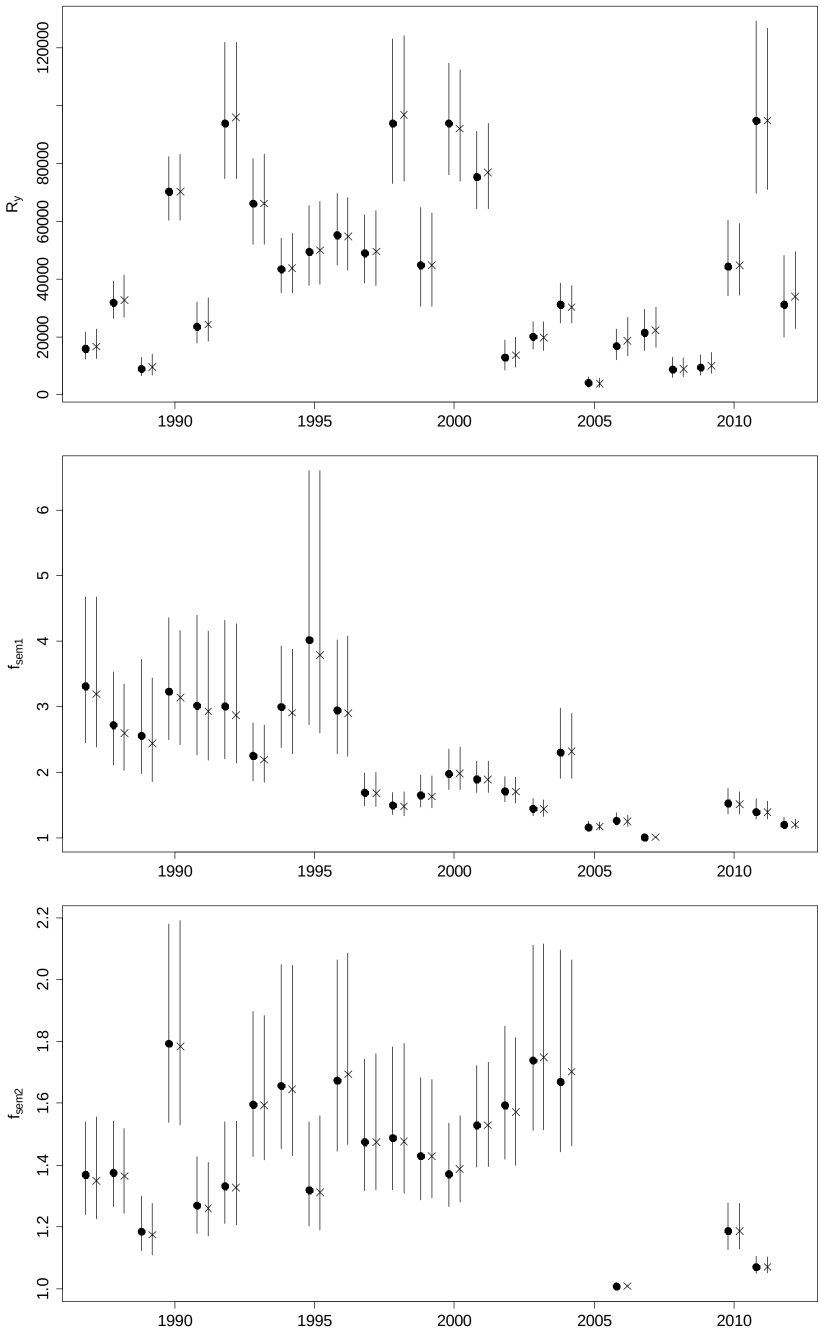
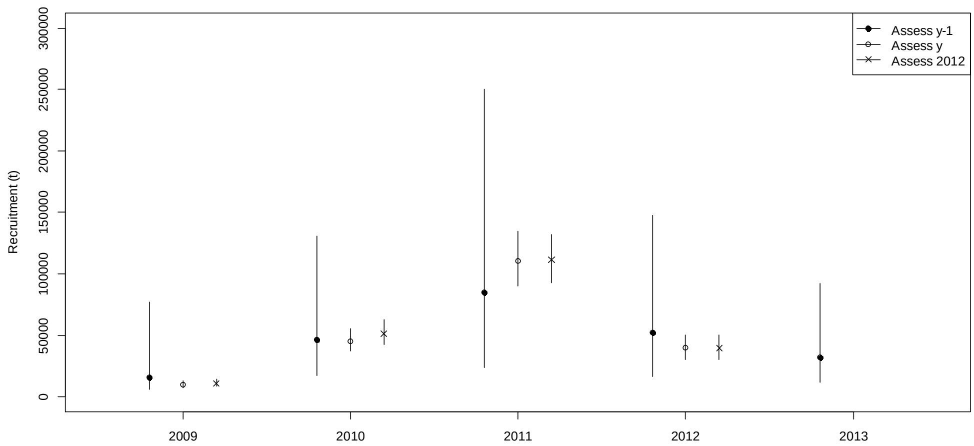


Figure 4: From top to bottom comparison of recruitment and fishing mortalities in the first and in the second semester for the linear (bullet) and the power (cross) model for the JUVENA index. The variance setting is the same as in Annex 3 of WKPELA.



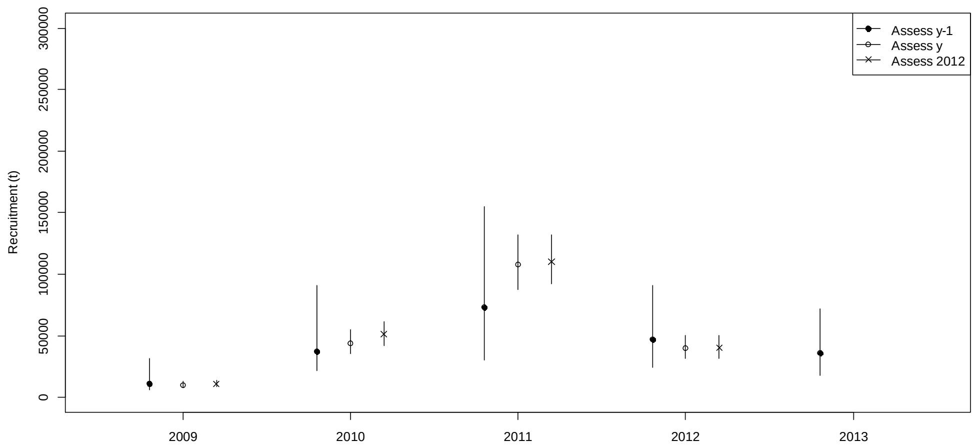
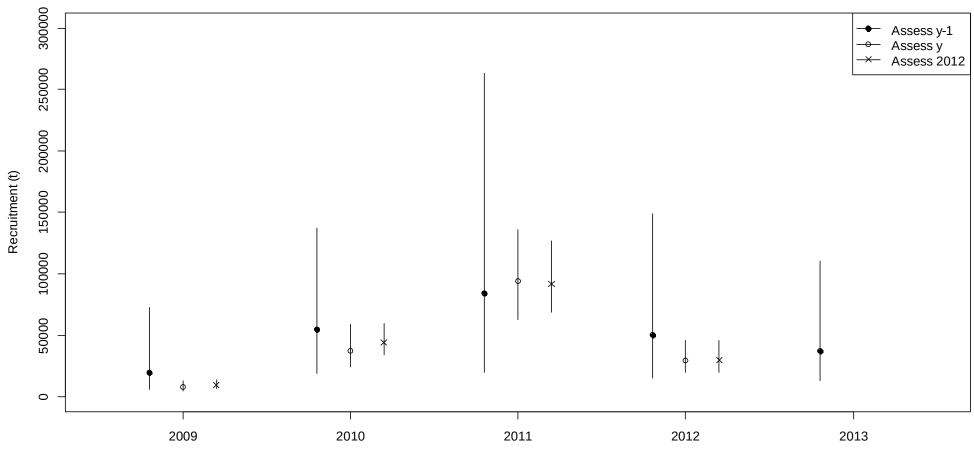


Figure 5: Comparison of recruitment as predicted in the December assessment using only the JUVENA index (bullet), as estimated in the December assessment once the latest spring surveys indices and catch data are included (open circle) and as estimated in the last assessment conducted in December 2012 (cross). The top panel correspond to the linear and the bottom panel to the power model for the JUVENA index. The variance setting is the same as in the stock annex of WKPELA.



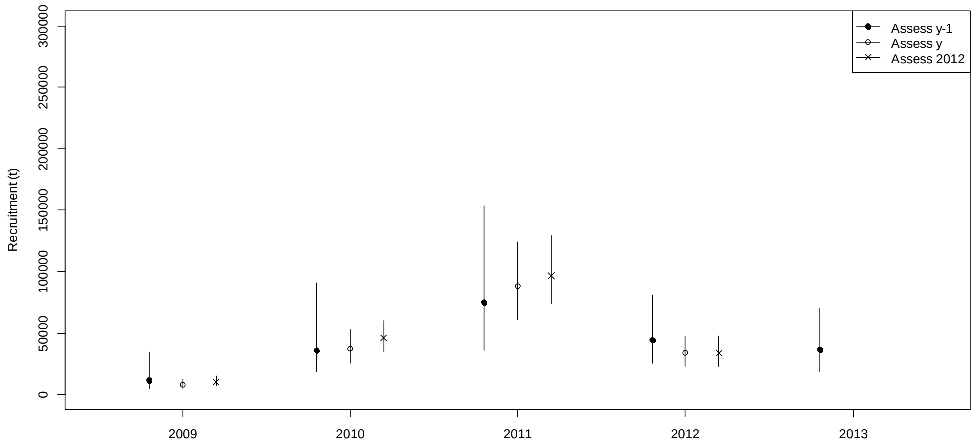


Figure 6: Comparison of recruitment as predicted in the December assessment using only the JUVENA index (bullet), as estimated in the December assessment once the latest spring surveys indices and catch data are included (open circle) and as estimated in the last assessment conducted in December 2012 (cross). The top panel correspond to the linear and the bottom panel to the power model for the JUVENA index. The variance setting is the same as in the Annex 3 of WKPELA.

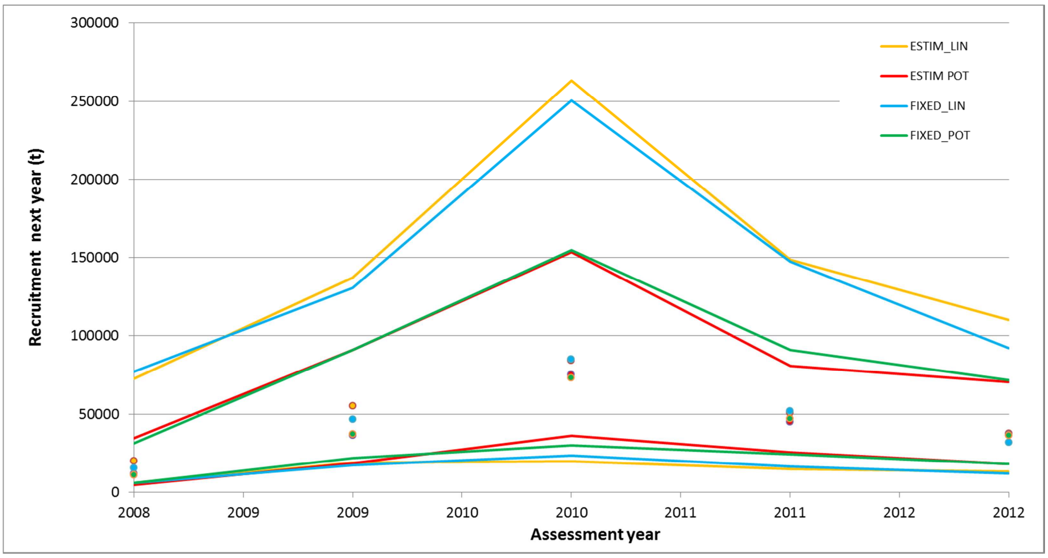


Figure 7: Comparison of recruitment as predicted in the December assessment using only the JUVENA index depending on whether the JUVENA observation equation corresponds to a linear or power model and on the variance settings chosen.

Table 1: Hyper-parameters and 5, 50 and 95 percentiles of the alternative prior distributions considered for the catchability of the JUVENA survey.

	Hyper-parameters	P_5	P_{50}	P_{95}
Prior 1 (WKPELA)	$\mu_{q_{juv}} = 0$ $\psi_{q_{juv}} = 2$	0.31	1	3.2
Prior 2	$\mu_{q_{juv}} = \ln(3)$ $\psi_{q_{juv}} = 1$	0.58	3	15.5
Prior 3	$\mu_{q_{juv}} = 0$ $\psi_{q_{juv}} = 0.1$	0.006	1	181.6

Table 2: Results comparison linear and power models for the case of variances fixed.

	VARIANCES FIXED			VARIANCES FIXED		
	LINEAR			POWER		
	DEPM relative			DEPM relative		
	$M_1 = 0.8$ and $M_{2+} = 1.2$			$M_1 = 0.8$ and $M_{2+} = 1.2$		
Parameter	5%	50%	95%	5%	50%	95%
q_{depm}	0.599	0.679	0.760	0.612	0.686	0.765
q_{ac}	1.269	1.436	1.613	1.295	1.453	1.619
q_{juv}	1.931	3.010	4.707	0.004	0.047	0.873
k_{juv}				1.126	1.421	1.669
ψ_{depm}						
ψ_{ac}						
ψ_{juv}	0.806	1.969	4.087	1.479	3.956	9.082
ξ_{depm}						
ξ_{ac}						
ξ_{catch}						
B_0	14883	17998	21895	14764	17863	21570
μ_R	9.979	10.300	10.630	9.974	10.290	10.610
ψ_R	0.700	1.128	1.709	0.708	1.127	1.702
$s(\text{sem}_1, 1)$	0.414	0.467	0.524	0.414	0.465	0.520
$s(\text{sem}_2, 1)$	1.241	1.456	1.704	1.212	1.436	1.689
G_1	0.497	0.569	0.648	0.498	0.573	0.654
G_{2+}	0.210	0.283	0.368	0.214	0.286	0.368
ψ_G	15.499	24.830	37.841	15.0995	24.575	37.081

Table 3: Results comparison linear and power models for the case of variances fixed plus estimated.

	VARIANCES FIXED+ ESTIM			VARIANCES FIXED + ESTIM		
	LINEAR			POWER		
	DEPM relative			DEPM relative		
	$M_1 = 0.8$ and $M_{2+} = 1.2$			$M_1 = 0.8$ and $M_{2+} = 1.2$		
Parameter	5%	50%	95%	5%	50%	95%
q_{depm}	0.521	0.630	0.766	0.509	0.621	0.756
q_{ac}	1.082	1.330	1.669	1.050	1.306	1.625
q_{juv}	1.824	3.083	5.124	0.001	0.018	0.714
k_{juv}				1.151	1.519	1.812
ψ_{depm}	3.507	6.528	12.141	3.618	6.724	12.371
ψ_{ac}	3.242	6.742	13.640	3.409	6.862	13.802
ψ_{juv}	0.618	1.582	3.406	1.278	4.083	14.120
ξ_{depm}	3.292	4.114	5.885	3.105	3.952	4.962
ξ_{ac}	2.676	3.484	4.201	2.676	3.442	4.106
ξ_{catch}	2.383	2.811	3.230	2.405	2.849	3.278
B_0	16815	21895	28001	16464	21939	28283
μ_R	10.030	10.350	10.670	10.040	10.370	10.690
ψ_R	0.692	1.131	1.720	0.698	1.151	1.748
$s(\text{sem}_1, 1)$	0.398	0.479	0.587	0.408	0.487	0.586
$s(\text{sem}_2, 1)$	1.052	1.323	1.633	1.048	1.307	1.627
G_1	0.457	0.526	0.598	0.455	0.525	0.599
G_{2+}	0.169	0.230	0.303	0.165	0.232	0.304
ψ_G	19.130	29.800	42.751	19.089	29.36	42.571

Table 4: Retrospective pattern in the median biomass when variance settings are the same as in the stock annex in WKKPELA. The columns correspond to the assessment year and the rows to each estimated year.

	VAR FIX and LINEAR								VAR FIX and POWER							
	2012	2011	2010	2009	2008	2007	2006	2005	2012	2011	2010	2009	2008	2007	2006	2005
1987	0.00	0.03	0.05	0.06	0.13	0.13	0.19	0.21	0.00	0.03	0.05	0.07	0.12	0.16	0.19	0.24
1988	0.00	0.04	0.05	0.05	0.12	0.12	0.17	0.20	0.00	0.03	0.04	0.06	0.10	0.15	0.16	0.20
1989	0.00	0.05	0.06	0.07	0.15	0.15	0.22	0.24	0.00	0.04	0.05	0.08	0.12	0.18	0.20	0.23
1990	0.00	0.03	0.04	0.05	0.10	0.10	0.15	0.18	0.00	0.02	0.04	0.04	0.09	0.12	0.13	0.16
1991	0.00	0.04	0.05	0.07	0.13	0.14	0.21	0.23	0.00	0.03	0.06	0.07	0.13	0.17	0.20	0.22
1992	0.00	0.05	0.06	0.08	0.14	0.14	0.21	0.26	0.00	0.03	0.06	0.08	0.13	0.17	0.20	0.23
1993	0.00	0.03	0.04	0.05	0.10	0.11	0.16	0.19	0.00	0.02	0.04	0.05	0.10	0.13	0.15	0.18
1994	0.00	0.04	0.05	0.06	0.11	0.12	0.17	0.19	0.00	0.02	0.05	0.06	0.10	0.14	0.15	0.18
1995	0.00	0.02	0.05	0.06	0.11	0.12	0.17	0.19	0.00	0.01	0.05	0.06	0.11	0.15	0.15	0.17
1996	0.00	0.02	0.05	0.06	0.12	0.13	0.17	0.19	0.00	0.02	0.05	0.07	0.11	0.15	0.16	0.18
1997	0.00	0.03	0.06	0.07	0.13	0.14	0.19	0.20	0.00	0.02	0.06	0.07	0.12	0.16	0.17	0.19
1998	0.00	0.03	0.05	0.06	0.12	0.13	0.18	0.20	0.00	0.02	0.06	0.07	0.12	0.16	0.17	0.20
1999	0.00	0.03	0.05	0.05	0.11	0.12	0.16	0.17	0.00	0.02	0.04	0.06	0.10	0.15	0.15	0.17
2000	0.00	0.05	0.06	0.07	0.14	0.15	0.21	0.24	0.00	0.05	0.06	0.07	0.13	0.17	0.19	0.22
2001	0.00	0.04	0.05	0.06	0.13	0.15	0.20	0.23	0.00	0.03	0.05	0.06	0.13	0.17	0.19	0.21
2002	0.00	0.04	0.06	0.07	0.14	0.16	0.21	0.22	0.00	0.03	0.05	0.07	0.13	0.18	0.20	0.21
2003	0.00	0.04	0.05	0.06	0.12	0.13	0.18	0.17	0.00	0.03	0.05	0.06	0.11	0.15	0.17	0.15
2004	0.00	0.04	0.06	0.07	0.14	0.14	0.20	0.09	0.00	0.03	0.05	0.06	0.12	0.16	0.18	0.08
2005	0.00	0.05	0.08	0.09	0.17	0.17	0.22	-0.01	0.00	0.05	0.07	0.08	0.14	0.19	0.20	-0.02
2006	0.00	0.05	0.06	0.07	0.12	0.11	0.07		0.00	0.05	0.06	0.07	0.10	0.12	0.05	
2007	0.00	0.05	0.04	0.05	0.05	-0.01			0.00	0.05	0.05	0.05	0.04	0.00		
2008	0.00	0.05	0.05	0.03	-0.05				0.00	0.04	0.03	0.02	-0.07			
2009	0.00	0.05	0.03	-0.04					0.00	0.04	0.02	-0.04				
2010	0.00	0.04	-0.11						0.00	0.02	-0.13					
2011	0.00	0.00							0.00	-0.02						
2012	0.00								0.00							
LAST YEA	0.00	0.00	-0.11	-0.04	-0.05	-0.01	0.07	-0.01	0.00	-0.02	-0.13	-0.04	-0.07	0.00	0.05	-0.02
AVERAGE	0.00	0.04	0.04	0.06	0.11	0.13	0.18	0.19	0.00	0.03	0.04	0.06	0.10	0.15	0.17	0.18

Table 5: Retrospective pattern in the median biomass when variance settings are the same as in the Annex 3 in WKKPELA. The columns correspond to the assessment year and the rows to each estimated year.

	VAR ESTIM and LINEAR								VAR ESTIM and POWER							
	2012	**2011**	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2012**	**2011**	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**
1987	0.00	-0.01	-0.02	0.01	0.02	0.05	0.07	0.14	0.00	-0.01	0.00	0.00	0.01	0.06	0.08	0.09
1988	0.00	0.00	0.00	0.01	0.04	0.05	0.08	0.16	0.00	-0.03	-0.01	-0.01	0.00	0.05	0.07	0.08
1989	0.00	0.00	0.01	0.01	0.06	0.06	0.11	0.24	0.00	-0.05	-0.01	0.00	-0.02	0.05	0.08	0.08
1990	0.00	0.02	0.01	0.01	0.04	0.04	0.07	0.11	0.00	0.01	0.01	-0.01	0.02	0.04	0.04	0.07
1991	0.00	0.06	0.05	0.05	0.09	0.07	0.14	0.14	0.00	0.03	0.04	0.02	0.04	0.09	0.06	0.06
1992	0.00	0.02	0.03	0.06	0.08	0.05	0.11	0.16	0.00	0.04	0.04	0.02	0.06	0.07	0.10	0.12
1993	0.00	0.02	0.03	0.06	0.06	0.07	0.09	0.13	0.00	0.01	0.01	0.01	0.04	0.05	0.06	0.08
1994	0.00	0.01	0.04	0.07	0.08	0.09	0.11	0.16	0.00	0.00	0.02	0.02	0.05	0.06	0.07	0.10
1995	0.00	0.01	0.03	0.05	0.06	0.07	0.09	0.15	0.00	-0.02	0.00	0.01	0.08	0.05	0.06	0.11
1996	0.00	0.01	0.02	0.04	0.07	0.07	0.10	0.15	0.00	-0.02	-0.02	-0.01	0.04	0.03	0.07	0.09
1997	0.00	0.01	0.06	0.07	0.10	0.09	0.14	0.14	0.00	0.00	0.01	0.00	0.04	0.04	0.08	0.08
1998	0.00	0.01	0.08	0.11	0.15	0.13	0.18	0.22	0.00	0.02	0.07	0.05	0.09	0.12	0.14	0.16
1999	0.00	0.01	0.03	0.07	0.10	0.06	0.13	0.12	0.00	-0.01	0.01	0.01	0.04	0.05	0.07	0.08
2000	0.00	0.01	-0.01	0.03	0.04	0.04	0.08	0.07	0.00	0.00	-0.03	-0.03	0.02	0.01	0.04	0.04
2001	0.00	0.01	0.01	0.04	0.06	0.06	0.10	0.08	0.00	0.01	0.00	0.00	0.04	0.05	0.07	0.05
2002	0.00	0.03	0.04	0.07	0.11	0.08	0.15	0.12	0.00	0.03	0.03	0.05	0.05	0.10	0.11	0.08
2003	0.00	0.02	0.01	0.02	0.06	0.03	0.08	0.02	0.00	0.02	0.00	0.00	0.02	0.03	0.04	0.00
2004	0.00	0.03	0.02	0.03	0.07	0.00	0.06	-0.07	0.00	0.01	-0.02	-0.04	0.01	-0.01	0.02	-0.10
2005	0.00	0.05	0.02	0.03	0.06	-0.05	0.03	-0.20	0.00	0.01	-0.05	-0.08	-0.03	-0.05	-0.03	-0.23
2006	0.00	0.06	0.03	0.01	-0.03	-0.18	-0.13		0.00	0.03	-0.03	-0.10	-0.15	-0.21	-0.23	
2007	0.00	0.06	0.00	-0.04	-0.12	-0.30			0.00	0.02	-0.06	-0.14	-0.21	-0.32		
2008	0.00	0.07	0.01	-0.05	-0.18				0.00	0.01	-0.05	-0.14	-0.25			
2009	0.00	0.06	0.00	-0.10					0.00	0.01	-0.05	-0.17				
2010	0.00	0.04	-0.15						0.00	-0.02	-0.18					
2011	0.00	0.03							0.00	-0.08						
2012	0.00								0.00							
LAST YEAI	0.00	0.03	-0.15	-0.10	-0.18	-0.30	-0.13	-0.20	0.00	-0.08	-0.18	-0.17	-0.25	-0.32	-0.23	-0.23
AVERAGE	0.00	0.02	0.01	0.03	0.05	0.03	0.09	0.11	0.00	0.00	-0.01	-0.02	0.00	0.02	0.05	0.05

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Reference points for the Iberian sardine stock (ICES areas VIIIc and IXa)

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Abstract

Three Yield-Per-Recruit/stock-recruitment approaches (deterministic, stochastic with plotMSY and stochastic with HCS) were used to explore reference points for the management of the Iberian sardine. The sensitivity of reference points was evaluated in relation to alternative scenarios of productivity, growth and selectivity. Growth and selectivity scenarios had a small impact on stock projections whereas productivity scenarios were very influential. The three approaches gave coherent results, but the approach using HCS, assuming uncertainty in stock biology and recruitment dynamics, was preferred to derive reference points for sardine. In this approach, the risks of the stock falling below some low biomass level can also be taken into account. This possibility was considered to be useful in the case of the sardine for which exploitation at maximum YPR or F0.1 resulted in values above historical exploitation and higher than Floss, therefore unsuitable as precautionary management targets.

Bloss (306 thousand t) is proposed as a proxy for Blim but given no indication that recruitment is impaired below this biomass level, the group considers that the level of risk of falling below this candidate for Blim acceptable in the evaluation of a management plan should be higher than the standard ICES value (5%).The stock productivity has declined over time; therefore a scenario of low productivity was assumed (recruitment in the period 1993-2010). Under this productivity scenario, the Fmsy value for the sardine stock is 0.34, a value associated with a high probability (45%) of the biomass falling below the proposed Blim and therefore, incompatible with precautionary considerations. The WG proposes an F= 0.27, corresponding to a Prob(B<Blim)<15% under equilibrium, as the best available candidate for an F management target (proxy for Fmsy) assuming the low productivity scenario (since 1993) will continue in the future. This F provides high yield conditional to a low probability that the biomass falls below Blim=Bloss in equilibrium, thus incorporating precautionary considerations.

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1. Introduction

The Iberian sardine stock assessed by ICES covers the Atlantic waters of the Iberian Peninsula (ICES areas VIIIc and IXa), extending from the Strait of Gibraltar in the south to the border with France in the Inner Bay of Biscay in the north.

The historical series of Iberian sardine catches used in the assessment goes back to 1978 and is provided by the national laboratories of both Spain and Portugal. During the last decades, catches have exhibited some fluctuations, peaked in 1981 at 217 thousand t, and thereafter showing a general decrease (Figure 1.1).

An age structured stock assessment model, Stock synthesis 3 (Methot, 2012) is applied since the last benchmark assessment (ICES, 2012a) to fishery dependent and independent data (acoustic and DEPM surveys) to derive estimates of population abundance, recruitment and fishing mortality. Recruitment has extensive variability showing peak values with some regularity (Figure 1.2; Table 1). A time series analysis of recruitment indicated a significant autocorrelation at lag 1 year and cyclical variations of 4-5 years (Santos et al. 2011). Both the level of recruitment and stock productivity (number of recruits per spawner) show a downward trend over time which appears to be partly explained by the environment (Solari et al. 2010; Santos et al. 2012; Figure 1.2, Annex 1) . The historical biomass shows extensive variation as well (Figure 1.2; Table 1). The higher levels calculated in the assessment, from the early 1990's, indicate that sardine population may have been more than two times its actual size. This has been routinely observed in pelagic fish populations all around the world showing drastic variations in size, with population crashes and sudden recoveries (Schwartzlose et al, 1999).

Reference points were proposed in the last benchmark assessment for this stock (ICES, 2012a) but were not accepted (see ICES 2012b, Technical minutes of the ADGHANSA). This WD proposes reference points for the management of sardine. Three approaches, deterministic YPR, stochastic YPR with plotMSY and stochastic YPR with HCS, were used to explore reference points. In all cases, YPR analyses were combined with recruitment dynamics. An overview of the literature on environmental effects on sardine recruitment and its trophic role in the ecosystem as well as stock recruitment and reference points for other sardine stocks was undertaken (Annex 1) to support the discussion of approaches and scenarios considered in the present WD.

2. Materials and methods

2.1 Input data

The exploration of reference points was based on data from the last sardine assessment (ICES, 2012b) (see note about F estimates[1]). As in ICES (2012b), recruitment (Age 0) estimated in the final year of the assessment, 2011, was not accepted since there is no data from the acoustic survey in the interim year (2012). Therefore, the 2011 recruitment was excluded from the fit of stock recruitment relationships. Moreover, the population at age 1 in the beginning of 2012 was re-calculated.

The initial population is the population at 1 January 2012 estimated in the assessment, except for age 1. Numbers-at-age 1 in the beginning of 2012 were obtained projecting from the geometric mean recruitment in 1993-2010, RGM(93-10) = 9028 billion individuals in 2011 with $F_{0,2011}$ and $M_{0,2011}$ (see section 2.1.1) The CVs for numbers at ages 1-6+ were assumed to be equal to the CVs estimated by the assessment model for the 2011 population. Numbers-at-age 0 in 2012 were equal to the RGM(93-10) = 9028 billion individuals. A CV=0.5 corresponding to the CV of log recruitment in 1993-2010 was taken.

Natural mortality was assumed to be equal to that in the assessment. Uncertainty to this parameter was not taken into account.

In the last sardine benchmark (ICES, 2012a), it was decided to adopt the biomass of age 1 and older individuals, B1+, as an indicator of spawning biomass for this stock. In this WD, where a maturity ogive needs to be input, a knife-edge ogive with 100% mature at age 1+ with no uncertainty is considered. Moreover, B1+ is the reference biomass used for the estimation of stock recruitment relationships and calculation of candidate reference points.

The lowest observed biomass in the stock history, Bloss=306 thousand t, is the estimate of biomass in the year 2000.

As in the assessment, the reference fishing mortality was the mean of ages 2-5, F(2-5).

[1] F-at-age and reference F's reported in WGHANSA 2012 were calculated as $–LN(N_{a+1,t+1}/N_{a,t})$ minus M from the model estimates of population N-at-age; however, to calculate Z for age 5 (maxage-1), SS3 includes numbers for the 6+ group in the same year, i.e. $–LN(N_{6,y+1}/(N_{5,y}+N_{6,y}))$. Fs for age 5 and consequentely mean F(2-5) are therefore misreported in WGHANSA 2012. For the purpose of this WD, correct Fs for age 5 and reference Fs were calculated multiplying age5-selectivity by apical F by year (Table 1). The correct F-reference is higher than the F-reference in WGHANSA 2012 with differences of 2-7% up to 1990 and 7-18% since 1991.

2.1.1 Scenarios of recruitment

Despite little or no unequivocal evidence of a clear regime shift, at least at a regional scale (Annex 1), the historical stock dynamics suggests sardine productivity has declined over time. The mean productivity of the stock across the whole historical period may not be representative of future productivity. The mean stock productivity in some recent period is a plausible scenario for future stock dynamics.

The selection of a period that represents the current level of productivity is not easy since there is no abrupt shift or clear transition in the time series (Figure 1.2). Nevertheless, the historical series suggests recruitment in approximately the last 20 years is at a lower level than recruitment in the early 20-25 years of the series (Figure 2.1). At the same time a wider range of biomasses is covered in the early than in the recent period. We used a simple regression tree to decide objectively in which year to split the series: this turned out to be 1992. Therefore we selected the period 1993-2010 as representative of current productivity. During this period, recruitment looks approximately stationary (Figure 2.1).

Based on the above productivity periods, two recruitment scenarios are considered in the exploration of reference points:

- Low recruitment: assumes future productivity will be at the level of the recent mean productivity in 1993-2010. The geometric mean recruitment, RGM(93-10)= 9028 billion recruits (stochastic projections), or the arithmetic mean recruitment, RAM(93-10)= 10224 billion recruits (deterministic projections), are used in the projection of the stock.

- Mean recruitment: assumes future productivity will be at the level of the historical mean productivity in 1978-2010. The geometric mean recruitment, RGM(78-10)= 12896 billion recruits (stochastic projections), or the arithmetic mean recruitment, RAM(78-10)= 15556 billion recruits (deterministic projections), are used in the projection of the stock.

2.1.2 Scenarios of growth

Historical weights at age show an increase over time. This increase is seen in catch weights since 1991 and in stock weights since 1989 but may have started earlier (in earlier years, fixed weights are used in the assessment; a fixed catch weight of 0.1Kg is used for age 6+). The weight increase is significant for all age groups in the catches and most age groups in the stock (2-4 and 6+) (Figure 2.2). Weight trends might reflect an improve of sardine condition possibly associated to enhanced feeding rate and efficiency induced by temperature noticed since the early 1970s (Silva et al. 2010).

Two scenarios for stock/catch weights-at-age were explored:

- Mean growth: assumes future growth will be equal to historical mean growth. Catch weights-at-age are mean values of 1991-2011 and stock weights-at-age are mean values of 1989-2011. Uncertainty in weights-at-age correspond to the CVs in these periods and therefore include both inter-annual variability and trend.
- High growth: assumes future growth will be equal to mean growth in recent years (as in short term predictions). Both catch and stock weights-at-age are mean values of 2009-2011. CVs were calculated after de-trending the historical series of weights-at-age (since 1991 for catch weights and since 1989 for stock weights). For that, weight was regressed on year separately for each age and CVs were calculated from the residuals scaled to the 2009-2011 mean (Table 2.1). In this case, CVs include only inter-annual variability.

2.1.3 Scenarios of fishery selectivity

In the assessment, fishery selectivity is assumed to vary over time as a random walk in the earlier part of the assessment period, 1978-1990. From 1991 to 2011 selectivity-at-age is fixed over time. The transition between the two periods takes place approximately between 1988 and 1991 and is also made according to a random walk. Age 0 is the reference age and selectivity at ages 4-5 is assumed to be equal to selectivity at age 3.

Younger ages (1-2) and the 6+ group had generally higher selectivity in the earlier than in the recent part of the assessment period (Table 2.2). The opposite is seen for ages 3-5.

Two scenarios of selectivity were considered (Table 2.2):

- Older fish selection: assumes future selectivity will be equal to selectivity in the recent part of the assessment period, 1991-2011

- Younger fish selection: assumes future selectivity will be equal to the mean selectivity in the earlier part of the assessment period, 1978-1987 (excluding the transition phase).

In both scenarios, uncertainty corresponds to the CVs estimated by SS3 (i.e. standard deviations for selectivity parameters on the log scale) and therefore represents the precision of selectivity estimates. For age 0 the CV is assumed to be zero and for ages 4-5 it is assumed to be equal to that of age 3.

2.2 Calculation of candidate reference points

A base case scenario was set up with input data listed in Table 2.3. The base case considers the following recruitment, growth and selectivity scenarios:

- Low recruitment: mean recruitment is RGM (93-10) or RAM(93-10)
- Mean growth: weights-at-age are mean values of 1989-2011(stock) or 1991-2011 (catch)
- Older fish selection: selectivity-at-age is the selectivity in the period 1991-2011

Not all alternative scenarios were used in all approaches to calculate reference points. Moreover, variants of low productivity/recruitment scenarios are explored in the deterministic and HCS projections. Further details on the input data and options are described in the corresponding sections.

2.2.1 Deterministic reference points.

An Excel spreadsheet was designed to carry out deterministic YPR analyses using the input data for the base case scenario. The alternative scenarios of mean recruitment, and high growth were explored (Table below). The sensitivity of reference points relative to a scenario of very poor recruitment was also tested. This scenario, **lowest mean recruitment,** considers the downward trend in productivity is halted but recruitment will remain at the lowest range of the historical series, RGM=6243 billion recruits and RAM=6757 billion recruits. In all cases, both RGM and RAM alternatives were explored.

Case	Scenarios		
	Recruitment	Growth	Selectivity
Base case	Low	Mean	Older fish
Case 1	Low	High	Older fish
Case 2	Mean	Mean	Older fish
Case 3	Mean	High	Older fish
Case 4	Lowest	Mean	Older fish
Case 5	Lowest	High	Older fish

Fishing mortality levels from the YPR analysis (i.e., independent of the recruitment level), F35%B1+, F40%B1+, F50%B1+, F60%B1+ and F0.1 were calculated. Fmed and Floss, as well as their corresponding biomasses, were also considered of interest for the discussion of reference points. Fmed was calculated as the fishing mortality yielding, in the YPR analysis, the B1+/R inverse to the median of the R/B1+ series of pair data points. Floss is the fishing mortality producing Bloss, conditioned to the recruitment geometric or arithmetic mean values of the hypothesis of productivity being tested.

2.2.2 Stochastic YPR using plotMSY

Yield per recruit and MSY reference points and, their associated uncertainties were estimated by means of the plotMSY software (WKMSYREF2013). Estimates of Fmsy were based on the combination of the three common stock recruit relationships: Ricker, Beverton-Holt and Hockey stick (approximated by a continuous function). The software default weighting of the stock recruitment relationships was used. The procedure for weighting by likelihood is to calculate the harmonic mean H_i for each model i using the number of samples given by the number of iterations, then to allocate a weighting to model i as follows: $H_i/\Sigma_i H_i$. A thousand iterations were output.

Input data are those listed in Table 2.3. Two runs were carried out, one with the base case recruitment scenario (low recruitment) and another one with the mean recruitment scenario.

2.2.3 Stochastic YPR using HCS13_3

Stochastic YPR runs were carried out with the software HCS13_3 (Skagen, 2013). The base case scenario was considered with input data listed in Table 2.3 except that uncertainty in selectivity-at-age was not taken into account. The stock recruitment function is a Hockey stick with Rmax=RGM (93-10) and a breakpoint at Bloss= 306 thousand t. Recruitment was assumed to be log-normally distributed with sigma=0.5. The random noise multiplier on recruitment was constrained to vary between 0.3 and 3 to avoid randomly drawn recruitments outside the range of historical recruitments. This range comes from trials to fit the estimated to the historical recruitment distribution.

The population was projected 98 years with constant fishing mortality (**target F**) in the range 0.0-1.0 and no observation or implementation error.

The software provides mean values and percentiles (10,50,90) of catch, biomass and fishing mortality calculated over all the bootstrap replicas for each target F value in the last year of the projection period.

A risk of B1+ <Bloss is calculated as the percentage of trajectories where biomass falls below the Bloss value in year 98. A risk of crashing the stock (B1+<1/10*Bloss) is calculated as the percentage the percentage of trajectories where biomass falls below 1/10*Bloss accumulated over the projection period.

The following statistics were considered to be of interest to discuss candidate reference points:

1. For a probability lower than 5% of B1+ being below Bloss
    - Mean value and percentiles of the equilibrium fishing mortality
    - Mean value and percentiles of the equilibrium catch (corresponding to F above)
    - Mean value and percentiles of the equilibrium biomass (corresponding to F above)
2. The maximum equilibrium fishing mortality, the corresponding catch and biomass (MSY proxies)

Values of fishing mortality considered in point 1 are related to the maximum fishing mortality which, with high probability, keeps the stock biomass above Bloss assuming equilibrium conditions. These are named PSY values (for precautionary and sustainable yield). Values of F below F_PSY are associated with a probability of B1+<Bloss lower than 5%. For each target F there is a range of realized Fs which reflect uncertainty in input data.

The alternative scenarios considered are summarized in the Table below:

Case		Scenarios			
		Recruitment	HS breakpoint	Growth	Selectivity
Base case	a	Low	Bloss=306	Mean	Older fish
	b		Low=250	Mean	Older fish
	c		High=350	Mean	Older fish
Case 2				High	Older fish
Case 3				Mean	Younger fish
Case 4		Mean	Bloss=306	Mean	Older fish

Within the base case scenario, the sensitivity of the reference points to bias in the breakpoint of the stock recruitment model was also tested (Cases 1b and 1c). Options for breakpoints for the Hockey stick take into account uncertainty in Bloss. The base case scenario assumes the breakpoint of the Hockey stick curve is at Bloss since there is no evidence of impaired recruitment below Bloss. The location of the breakpoint is unknown and, depending on the model and software used, can be placed within a wide range of biomasses (e.g. 287 thousand t in FLR, 357 thousand t in plotMSY). Assuming such differences illustrate at least part of the uncertainty in the breakpoint and taking also into account the average CVs of biomass in the assessment (~16%) we compared the base case with alternatives assuming a breakpoint at Bloss±16%.

In case 4 recruitment was assumed to be log-normally distributed with sigma=0.62. This sigma corresponds to the CV of log recruitment in 1978-2010, the period representing the mean productivity scenario.

3. Results

Preliminary work was carried out to explore a range of stock recruitment models using FLR. The results are summarized in Annex 2.

3.1 Deterministic Reference Points

F reference points derived from the YPR curve and corresponding biomass levels conditioned to the low recruitment scenario, RGM(93-10), can be seen in Table 3.1a (F0.1 corresponds to a %B1+ of 37.9%).

The results are consistent with corresponding median Fs produced by plotMSY software (section 3.2 and Table 3.4). Fmax is not placed within the range of Fmult <10 for which the workbook was run so it was perceived to be above 3.3. The plotMSY software pointed out to an Fmax around 3 (median=2.6). In any case well above any meaningful exploitation rate in terms of credible sustainability. The sensitivity of the F reference points to the high growth scenario (mean 2009-2011) is minimal (Table 3.1b).

Floss conditioned to the geometric mean value of the three recruitment scenarios being tested is presented in Table 3.2 (upper panel). The sensitivity to the use of the arithmetic mean was relevant (table 3.2. middle pannel). The sensitivity to the mean weights-at-age was minima (Table 3.2 bottom panel). According to ICES CM 2003/ACFM:15, in order to estimate Floss when no clear S-R relationship can be defined then the arithmetic average of the recruitment for the time series available is a candidate for the recruitment to be expected from the Bloss spawning biomass. Therefore from the tables 3.2 those referring to the arithmetic mean (since 1993) are to be preferred for Floss.

For a management seeking to avoid dropping biomass below Bloss, then F target should be below Floss. Assuming the recent low productivity of the stock, Floss is 0.51 (regardless of the mean weights being used). This implies that F0.1 and all F%B1+ corresponding to percentages of the virgin biomass below about 43% will not be sustainable in the long term because of being above Floss for the arithmetic mean R. Since Floss is dependent on the average level of recruitment, Floss would be substantially higher in the scenario of historical mean recruitment (at 1.08) and substantially lower (0.20) if the very recent low recruitment scenario (since 2006) would be maintained in the long term.

The median replacement lines for the two scenarios of stock productivity, mean (since 1978) and low (since 1993), have slopes of 0.021 and 0.018 thousands of recruits per kg of B1+, respectively (Figure 3.1). The slope (and therefore productivity) corresponding to the lowest recruitment scenario (since 2006) is very similar to that in the recent period (0.018). The inverse of those replacement lines correspond with B1+/R of 47.7, 54.2 and 54. 9 Kg per recruit and correspond with the Fmed values shown in Table 3.3. The sensitivity of Fmed to the use of the selected mean weights for the catches and the stock were minima and always below 10%

Fmed can be considered a sustainable fishing mortality at the average productivity of the stock preventing any clear tendency in the population level, i.e. keeping biomass around the mean of the period of consideration of the stock recruitment relationship.

For this stock Fmed for the low recruitment scenario (since 1993; 0.11) is well below Floss (0.51) and well below the historical average exploitation of the stock (0.31).

A summary of the results is shown in Figure 3.2.

3.2 Stochastic Reference points with plotMSY

The YPR and Biomass per recruit curves with corresponding quantiles are shown in Figure 3.3. Fishing mortality reference points based on the stochastic YPR model are presented in Table 3.4. Bmsy and MSY calculated from corresponding per recruit values at Fmax assuming the low and mean RGM recruitments (named Bmsy-low/mean and MSY-low/mean) are also shown in the table.

The fit of stock recruitment models to data from the low productivity period is shown in Figure 3.4. The number of samples that have feasible parameter estimates for stock recruitment models (i.e. alpha and beta are positive for the usual parameterisation of the functions) was 32 out of 1000 for the Ricker and the Smooth Hockey stick and 21 out of 1000 for the Berverton Holt. The ability to estimate stock recruitment parameters did not improve when data from the mean productivity period, 1978 – 2010, was used (not shown). The mean values of the Hockey stick Beta (breakpoint of the curve) were estimated to be 357 and 439 thousand t for the low (since 1993) and mean (since 1978) recruitment scenarios, respectively, both with CV=28%.

Fmsy estimates (50% percentiles) assuming the low recruitment scenario are higher for the Berverton-Holt (0.53) than for the Ricker (0.37) and for the Hockey stick (0.32). The combined Fmsy estimate (0.39) is intermediate between the Ricker and the Hockey stick estimates and slightly above F2010 (0.36) (Table 3.5). Assuming the mean level of recruitment (since 1978), the 50% percentile of Fmsy is 27% higher than that estimated with the low recruitment scenario.

Overall, candidate reference points explored with plotMSY, both derived from the stochastic YPR analyses (F35%, F40%, F0.1, Fmax), and from the combination of YPR with a stochastic stock recruitment model (Fmsy), are at the upper limit or above the historical range of fishing mortalities for the stock (see Table 1). Recent studies on low trophic level stocks recommend target fishing mortalities corresponding to percentages of virgin biomass higher 40% (Smith et al. 2011; Horbowy and Luzeńczyk 2012). For LTL species considered as key species in the ecosystem, this percentage could be as high as 75%B0. Sardine is an important prey species in the pelagic ecosystem. Preliminary results indicate that major sardine predators such as the common dolphin appear to adapt to changes in the abundance of sardine in the ecosystem (Annex 1). However, the trophic role of sardine in the ecosystem (key or non-key species) is still uncertain. Nevertheless, F values around F60%B1+ calculated in this WD (deterministic analysis) seem to be relatively consistent with the fishing mortality that will keep the probability of the stock B1+<Bloss below 5% (see section 3.3).

3.3 Stochastic YPR with HCS13_3

Table 3.6 presents the results for all cases explored with HCS. The equilibrium yield and biomass plots for the base case are shown in Figure 3.5.

Fmsy for the base case scenario is 0.34 corresponding to MSY= 82 thousand t and B1+=326 thousand t. At this fishing mortality level, the risk that B1+ is below Bloss is 45%. The risk is high (>=27%) in all alternative scenarios.

In the base case scenario, the maximum fishing mortality (F_PSY) that will keep the probability of B1+<Bloss below 5%, assuming equilibrium, is in the range 0.20-0.24 (median= 0.22) with corresponding yield in the range 54-90 thousand t (median=69). At this level of F the stock will fluctuate in the range 322-540 thousand t (median=414) being therefore at a relatively safe distance above Bloss. The distribution of modeled recruitments fits the distribution of historical recruitments generally well (Figure 3.6). However, high recruitment levels corresponding to recruitment pulses which occurred with some regularity in the past are less frequent in the modeled distribution than suggested in historical data.

The F corresponding to Bloss in this analysis is 0.35 (corresponding to about 52%B1+ for the recent mean weights) This Floss value is slightly below the Floss calculated deterministically with the geometric mean recruitment (=0.40).

Figure 3.7 plots the PSY values for cases 1-3. The impact of bias in the breakpoint of the Hockey stick model was relatively small providing median F_PSY values of 0.20 (high breakpoint) and 0.22 (low breakpoint). As in the deterministic approach, the impact of assuming alternative scenarios of growth (high growth) and selectivity (selection of younger fish) on F_PSY values were also small (Table 3.6).

On the contrary, as seen in the other approaches, the effect of assuming the mean recruitment scenario is substantial: compared to the base case, the 50% percentile of F_PSY and Yield_PSY double while the corresponding B1+ slightly improves (Table 3.6).

4. Discussion and CONCLUSION

The major challenges in the definition of reference points for sardine are the lack of information about biomass levels leading to impaired recruitment (Figure 2.1), the absence of a maximum in the yield per recruit curve within plausible fishing mortality levels (Figure 3.3) and changes in stock productivity over time (Figure 3.1). In this WD, we demonstrated how these aspects influence F reference points which are commonly adopted for the management of fish stocks.

Historical stock- recruitment estimates provide no indication of a biomass level below which recruitment is impaired which conforms to the strict concept of Blim. Recruitment dynamics below Bloss are unknown (the general Blim concept).

Given no indication of impaired recruitment below Bloss, this point could be taken as Bpa according to ICES guidelines (2003, 2011). ICES states that Bloss may be considered a proxy for Bpa in cases where the dynamic range of SSB in the stock-recruitment plot is narrow and the stock is lightly exploited. However, “narrow range” and “lightly exploited” have not been quantified and decisions should be made case by case (ICES, 2003). The sardine assessment covers 66% of the biomass range and the mean exploitation since 1993 (F2-5)=0.29 has been below natural mortality (M(2-5)=0.36) and Floss=0.35. Therefore, the adoption of Bloss as a proxy for Blim or Bpa is debatable.

However, there are some points of concern about recruitment dynamics, such as some downward trend over time, with indication of lower productivity since 1993 and persistent low recruitments in the last years (since 2006). For these reasons, the group considers Bloss=306 thousand t may be a candidate to evaluate the risk of the stock entering an uncertain biomass dynamic region (so as proxy for Blim). Nevertheless the group acknowledges the poor scientific basis for taking it as an inflection point leading to impaired recruitment dynamics. For this reason the risk of falling below this candidate for Blim value may deserve ad hoc considerations and/or consultation with managers and stakeholders. If needed, Flim could be derived from Floss=0.35, the equilibrium fishing mortality producing Bloss in the low productivity scenario.

F reference points obtained by the different approaches were generally consistent. Stochastic approaches are preferred since uncertainty in stock biology, selectivity and most importantly, in recruitment dynamics, is taken into account and reflected on reference points. In plotMSY, uncertainty in the form of the stock recruitment relationship can be taken into account and Fmsy obtained combining common SR models (Ricker, Berverton-Holt and Hockey stick) according to their fit to the data. However, for stocks with no clear stock recruitment relationship such as sardine, different models provide similarly uncertain fits and their combination does not improve the stock recruitment analysis. In HCS, the risks of the stock falling below some low biomass level can be taken into account in the stochastic YPR/stock-recruitment analysis. Thus, precautionary considerations can be added to the derivation of reference points. The group considers this approach to be useful in the case of the sardine for which exploitation at maximum YPR does not seem to be an appropriate management target.

As seen in all approaches, the assumed productivity/recruitment scenario is very influential in stock projections. In the HCS approach, the F target providing the highest yield conditional to a low (<5%) probability that the stock declines below Bloss is 0.42 when the complete historical mean productivity scenario (since 1978) is assumed and 0.22 when the low productivity scenario (since 1993) is assumed. On the other hand, the assumption of a very poor recruitment (since 2006) in the deterministic approach resulted in Floss=0.21.

Given evidence that stock productivity has declined over time, we considered a scenario where future productivity will be low, i.e. future recruitment will be, on average, at the level of the recruitments since 1993. This scenario, could arise if sardine productivity is associated with a persistent environmental change such as global warming. While such an association is uncertain (Annex 1) the relatively long phase of low productivity advises the adoption of a more conservative scenario instead of a scenario consistent with the mean historical productivity since 1978. The fact that high recruitments occurring in the period 1978-1992 are not appearing in similar frequency or strength since 1993 suggests that average fishing mortalities should require accommodation to this lower productivity of the stock, even if this productivity is largely environmentally driven.

The Fmsy value obtained for the sardine stock, assuming a low productivity scenario, is 0.34 (Table 3.6) corresponding to a yield of 82 thousand t. This F level seems to provide an optimistic perception of a sustainable harvest level which is incompatible with precautionary considerations. In fact, this F level is associated with a high probability (45%) of the biomass falling below Bloss (Table 3.6; Figure 3.5) in equilibrium conditions for the assumed low productivity of the stock.

Conditioning the derivation of a sustainable F by the Prob(B<Blim) allows the derivation of a level consistent with precautionary considerations. The assumption of a P(B<Blim)<5% (corresponding to F=0.22), the ICES standard value when there is no alternative indication from managers and stakeholders, would be too stringent in this case given that there is no indication of impaired recruitment at Bloss and there is large uncertainty about the interpretation of Bloss as Blim or Bpa. The group considered that a level of risk=15% could be acceptable to conciliate precautionary considerations with high sustainable yield (Table 3.7) given the current uncertainties on the meaning of Bloss. In fact, if Bloss would have been used as Bpa, an Fpa with a risk of leading below Bpa at the 10-25% percentiles would have been considered appropriate according to ICES 2001 guidelines (ICES 2001).

The F corresponding to a Prob(B<Blim)<15% is 0.27 (range 0.24-0.30) and provides a yield of 77 thousand t (range 59-101 thousand t). At this level of F the biomass will fluctuate around 387 thousand t (range 286-501) being therefore at a safe distance above Blim. F=0.27 is close but below the mean of 1993-2011 (0.29), a period when the biomass has fluctuated at a low level but showed no trend and lower than the historical mean (0.31, 1978-2010). This value is halfway in the range from the stringent F=0.22 to the Fmsy=0.34. Moreover, an F=0.27 should allow recovering the biomass in 5 years if it falls below Blim, with a certainty of ~94% (Table 3.8).

In conclusion, the group considers that F=0.27 it is the best available candidate for an F management target (proxy for Fmsy) assuming the low productivity scenario (since 1993) will continue in the future. This F provides high yield conditional to a low probability that the biomass falls below Blim=Bloss in equilibrium, thus incorporating precautionary considerations.

We note that the generation of recruitments in the stochastic modeling seems to reflect high recruitments in slightly less frequency than observed since 1993. In the past, the sardine stock has produced strong recruitments with some regularity (cycles of 4-5 years, Santos et al. 2011). These recruitments have had a key role in the dynamics of the stock raising the stock biomass 30-90% in the two following years and operating as a rescue when the stock is at a low level. However, intervals between high recruitments have been variable (3-8 years); and no strong recruitment has been observed since 2005. The historical series may not be sufficiently long to correctly quantify their frequency. The way recruitment has been simulated, might have been a bit cautious in comparison with the average productivity in the period 1993-2010. The proposed Fmsy corresponds to a low productivity scenario where good year classes are assumed to be a bit scarcer than in the past 18 years. Therefore, this Fmsy needs to be re-evaluated in some years as further information on recruitment dynamics and stock productivity becomes available. These considerations should also be taken into account in the evaluation of harvest control rules for the stock.

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Table 1 – Summary of the sardine stock assessment in 2012 (ICES 2012b)

Year		Biomass 1+	SSB	CV SSB	Recruits	CV Recruitment	F (2-5)	Apical F	CV apicalF	Landings
		'1000 t	'1000 t	%	Billion individuals	%	year-1	year-1	%	'1000 t
	1978	424	407	17	23921	15	0.37	0.46	16	146
	1979	464	433	16	27481	15	0.36	0.44	16	157
	1980	560	525	15	31471	14	0.36	0.43	15	195
	1981	659	618	14	19690	17	0.35	0.41	15	217
	1982	667	642	14	10956	23	0.34	0.38	15	207
	1983	572	558	16	49222	11	0.34	0.36	15	184
	1984	734	669	14	15381	18	0.33	0.36	15	206
	1985	781	761	13	14228	18	0.29	0.30	12	208
	1986	677	659	13	11676	19	0.32	0.33	14	187
	1987	584	569	14	23745	13	0.35	0.36	15	178
	1988	555	524	14	13148	17	0.35	0.36	18	162
	1989	545	528	14	12676	17	0.32	0.33	19	141
	1990	492	475	15	13119	17	0.40	0.41	18	149
	1991	475	453	16	36404	11	0.34	0.37	17	133
	1992	759	680	13	26193	12	0.25	0.27	17	130
	1993	898	853	13	11694	15	0.25	0.28	17	142
	1994	809	778	13	10038	14	0.22	0.24	15	137
	1995	818	792	13	7366	14	0.21	0.23	15	125
	1996	549	537	14	11478	12	0.27	0.29	16	117
	1997	483	458	15	6864	14	0.34	0.37	15	116
	1998	397	379	16	9057	13	0.39	0.42	16	109
	1999	363	343	17	7427	15	0.36	0.39	17	94
	2000	306	297	17	22968	12	0.32	0.35	18	86
	2001	453	413	16	13861	13	0.31	0.34	18	102
	2002	513	471	15	7685	15	0.26	0.28	19	100
	2003	462	448	16	5871	18	0.24	0.27	18	98
	2004	442	432	17	26221	11	0.26	0.29	18	98
	2005	520	407	17	9707	14	0.26	0.28	19	97
	2006	581	556	15	3341	18	0.22	0.24	18	87
	2007	537	525	15	5594	16	0.22	0.24	16	96
	2008	412	405	18	7511	17	0.31	0.34	18	101
	2009	336	323	19	11431	18	0.32	0.35	22	87
	2010	314	294	21	5910	22	0.36	0.40	23	90
	2011	330	330	22	11627	31	0.31	0.34	25	80
Mean 1978-2011		543	516	15	15440	16	0.31	0.34	17	134
Minimum 1978-2011		306	294	13	3341	11	0.21	0.23	12	80
Maximum 1978-2011		898	853	22	49222	31	0.40	0.46	25	217
Mean 1993-2011		501	476	16	10297	16	0.29	0.31	18	103
Minimum 1993-2011		306	294	13	3341	11	0.21	0.23	15	80
Maximum 1993-2011		898	853	22	26221	31	0.39	0.42	25	142

Table 2.1 – Input values for the growth scenarios: mean weights at age in the stock (a) and in the catch (b) for the whole period (mean growth scenario) and for the recent period (high growth scenario).

(a) Stock weights

	Whole period (1991-2011)		Trend over time		Recent period (2009-2011)	
Age	Mean	CV	Slope	Significance (p-value)	Mean	CV
1	0.024	0.24	-9.09E-05	0.665	0.021	0.26
2	0.043	0.13	4.74E-04	0.014	0.048	0.10
3	0.056	0.09	5.27E-04	0.001	0.059	0.07
4	0.065	0.08	3.23E-04	0.066	0.065	0.07
5	0.070	0.08	7.92E-05	0.689	0.066	0.08
6	0.081	0.16	-1.14E-03	0.009	0.071	0.15

(b)Catch weights

	Whole period (1989-2011)		Trend over time		Recent period (2009-2011)	
Age	Mean	CV	Slope	Significance (p-value)	Mean	CV
0	0.023	0.18	3.42E-04	0.004	0.023	0.14
1	0.041	0.13	4.74E-04	0.003	0.044	0.10
2	0.057	0.10	5.72E-04	0.000	0.063	0.06
3	0.066	0.08	7.20E-04	0.000	0.074	0.04
4	0.072	0.08	6.84E-04	0.000	0.079	0.05
5	0.077	0.07	5.32E-04	0.001	0.081	0.05
6	0.100	-	-	-	**0.100**	**0.10**

Table 2.2 – Input data for the two selectivity-at-age scenarios: older fish selction (mean of 1991-2011) and younger fish selection (mean of 2009-2011).

	Selectivity		
	1991-2011	1978-1987	
Age	Mean	Mean	CV
0	0.116	0.104	0
1	0.352	0.480	0.09
2	0.663	1.000	0.09
3	1.000	0.865	0.10
4	1.000	0.865	0.10
5	1.000	0.865	0.10
6	0.366	0.551	0.27

Table 2.3 – Input data for the base case scenario.

Age	Population		Natural mortality	Maturity	Stock weights		Catch weights		Selectivity	
	Number	CV			Mean	CV	Mean	CV	Mean	CV
0	9028	0.50	0.8	0	0.000	0	0.023	0.18	0.116	0
1	3898	0.23	0.5	1	0.024	0.24	0.041	0.13	0.352	0.09
2	1363	0.20	0.4	1	0.043	0.13	0.057	0.10	0.663	0.09
3	1390	0.23	0.3	1	0.056	0.09	0.066	0.08	1.000	0.10
4	472	0.28	0.3	1	0.065	0.08	0.072	0.08	1.000	0.10
5	184	0.34	0.3	1	0.070	0.08	0.077	0.07	1.000	0.10
6	612	0.39	0.3	1	0.081	0.16	0.100	0.10	0.366	0.27

Table 3.1 –F reference points from the deterministic YPR analysis, for the base case scenario (with RGM(1993-2010) (a). Table (b) shows the sensitivity to the use of recent weights-at-age.

(a)

Reference F	Biomass1+	FMult	Fbar(2-5)	Landings	Yield/R
F60% B1+	389	0.71	0.23	69	7.6
F50% B1+	324	1.07	0.36	85	9.4
F40% B1+	259	1.66	0.55	100	11.1
F35%B1+	227	2.12	0.71	108	11.9
F0.1	246	1.83	0.61	103	11.4

(b)

Reference F	Biomass1+	FMult	Fbar(2-5)	Landings	Yield/R
F60% B1+	374	0.76	0.25	78	8.6
F50% B1+	312	1.15	0.38	95	10.6
F40% B1+	250	1.77	0.59	112	12.4
F35% B1+	219	2.26	0.75	119	13.2
F0.1	169	1.84	0.61	78	12.5

Table 3.2 – Floss from the deterministis YPR analysis for the three recruitment scenarios and two growth scenarios: Upper panel for the geometric mean recruitment (mean weights since 1993), middle panel for the Arithmetic mean recruitment with mean weights since 1993 and bottom panel for the Arithmetic mean recruitment with mean weights since 1996.

Mean Weights earlyNineties-2011		Floss			
Recruitment series	Biomass1+	Fbar(2-5)	Landings	Yield/R	%B1+
GeomMean(1978-2010).Rec.	306,123	0.7812	157,474	12.2111	33.1%
GeomMean(1993-2010).Rec.	305,915	0.4006	89,373	9.8990	47.2%
Geom.Mean since 2006.Rec.	305,985	0.1642	38,278	6.1313	68.3%

Mean Weights since earlyNineties		Floss			
Recruitment series	Biomass1+	Fbar(2-5)	Landings	Yield/R	%B1+
Arithm.Mean(1978-2010).Rec.	306,024	1.0854	203,444	13.0785	27.4%
Arithm.Mean(1993-2010).Rec.	305,996	0.5103	110,658	10.8239	41.7%
Arithm.Mean since 2006.Rec.	306,199	0.2061	47,849	7.0810	63.1%

Mean Weights 2009-2011		Floss			
Recruitment series	Biomass1+	Fbar(2-5)	Landings	Yield/R	%B1+
Arithm.Mean(1978-2010).Rec.	306,071	1.0738	220,946	14.2037	28.5%
Arithm.Mean(1993-2010).Rec.	305,838	0.5086	120,724	11.8084	43.3%
Arithm.Mean since 2006.Rec.	305,885	0.1978	50,743	7.5092	65.5%

Table 3.3 – Fmed from the deterministis YPR analysis for the three recruitment scenarios: Upper panel for the mean growth and bottom panel for high growth scenario.

Mean Weights earlyNineties-2011			F med			
Recruitment series	Biomass1+	FMult	Fbar(2-5)	Landings	Yield/R	%B1+
GeomMean(1978-2010).Rec.	615,672	0.535	0.178	83,299	6.5	66.5%
GeomMean(1993-2010).Rec.	489,964	0.345	0.115	42,940	4.8	75.6%
Geom.Mean since 2006.Rec.	342,493	0.33	0.110	28,715	4.6	76.4%

Mean Weights 2009-2011			Fmed			
Recruitment series	Biomass1+	FMult	Fbar(2-5)	Landings	Yield/R	%B1+
GeomMean(1978-2010).Rec.	608,518	0.525	0.175	89,416	6.9	68.3%
GeomMean(1993-2010).Rec.	490,201	0.31	0.103	42,906	4.8	78.5%
Geom.Mean since 2006.Rec.	342,563	0.295	0.098	28,545	4.6	79.4%

Table 3.4 – F reference points from the stochastic YPR analysis with plotMSY. Bmsy and MSY are calculated from the per recruit values at Fmax for the low and the mean recruitment scenarios.

	F35	F40	F01	Fmax	Bmsy-low	MSY-low	Bmsy-mean	MSY-mean
Deterministic	0.71	0.56	0.61	3.00	290	93	414	133
Mean	0.74	0.57	0.57	2.56	352	80	503	114
5%ile	0.55	0.44	0.47	2.03	277	39	396	55
25%ile	0.63	0.50	0.52	2.41	313	74	447	105
50%ile	0.72	0.56	0.56	2.55	336	82	479	118
75%ile	0.81	0.62	0.60	2.78	379	91	541	130
95%ile	1.09	0.81	0.70	2.95	496	104	709	149
CV	0.22	0.20	0.13	0.12				

Table 3.5 –Fmsy and Fcrash from plotMSY analyses for the two recruitment scenarios.

	Low R scenario		Mean R scenario	
Percentage	Fmsy	Fcrash	Fmsy	Fcrash
5%	0.20	0.22	0.20	0.29
25%	0.28	0.40	0.32	0.50
50%	0.39	0.76	0.48	0.88
75%	0.54	2.02	0.68	1.88
95%	0.87	3.94	1.08	4.14

Table 3.6 – Results of the scenarios considered in the stochastic YPR analysis with HCS. The exact values of the Prob(B1+<Bloss) are shown for each scenario.

			F_PSY			B1+_PSY				Yield_PSY				Risk to Bloss at F_PSY	Fmsy	Bmsy	MSY	Risk to Bloss at Fmsy
Case	R scenario	HS breakpoint	10%	50%	90%	mean	10%	50%	90%	mean	10%	50%	90%					
Base case a	Low	306	0.20	0.22	0.24	426	322	414	540	71	54	69	90	5.4	0.34	326	82	44.5
b		250	0.20	0.22	0.24	428	325	417	540	71	55	70	90	4.8	0.46	291	96	61.2
c		350	0.18	0.20	0.22	436	327	425	554	66	50	65	84	6.1	0.26	365	71	26.7
Case 2		306	0.20	0.22	0.23	435	327	423	554	77	59	75	98	5.0	0.36	328	91	44.4
Case 3		306	0.16	0.18	0.20	436	331	425	549	69	53	68	88	4.2	0.28	339	83	38.0
Case 4	Mean	306	0.37	0.42	0.47	467	332	445	632	143	104	138	190	4.9	0.60	369	154	32.9

Table 3.7 –Detailed results of the base case scenario in the stochastic YPR analysis with HCS.

Target F	Cmean	C10	C50	C90	F10	F50	F90	Bmean	B10	B50	B90	Risk to Blim (%)	Risk of stock crash (%)
0.20	67	52	66	85	0.18	0.20	0.22	443	337	431	557	3	0
0.22	71	54	69	90	0.20	0.22	0.24	426	322	414	540	5	0
0.24	74	57	73	95	0.22	0.24	0.26	410	308	398	524	9	0
0.26	77	59	76	99	0.23	0.26	0.29	395	294	384	510	13	0
0.27	78	59	77	101	0.24	0.27	0.30	387	286	375	501	15	0
0.28	80	60	78	103	0.25	0.28	0.31	380	277	367	492	18	0
0.30	81	60	80	105	0.27	0.30	0.33	363	265	352	475	25	0
0.32	82	59	81	108	0.29	0.32	0.36	346	246	336	460	35	0
0.34	82	56	81	110	0.30	0.34	0.38	326	219	321	443	45	0
0.36	80	49	80	111	0.32	0.36	0.40	304	183	299	425	53	0.1

Table 3.8 – Probability of recovery of the biomass within 5 years when dropping below the breakpoint. All cases where the SSB dropped below the breakpoint are considered, and the percentage of those cases where SSB was above the breakpoint 5 years late is recorded.

F	Percent after 5 years
0.10	100
0.12	100
0.14	100
0.16	100
0.18	99
0.20	99
0.22	98
0.24	97
0.26	95
0.28	93
0.30	91
0.32	88
0.34	85
0.36	82
0.38	78
0.40	75
0.42	71

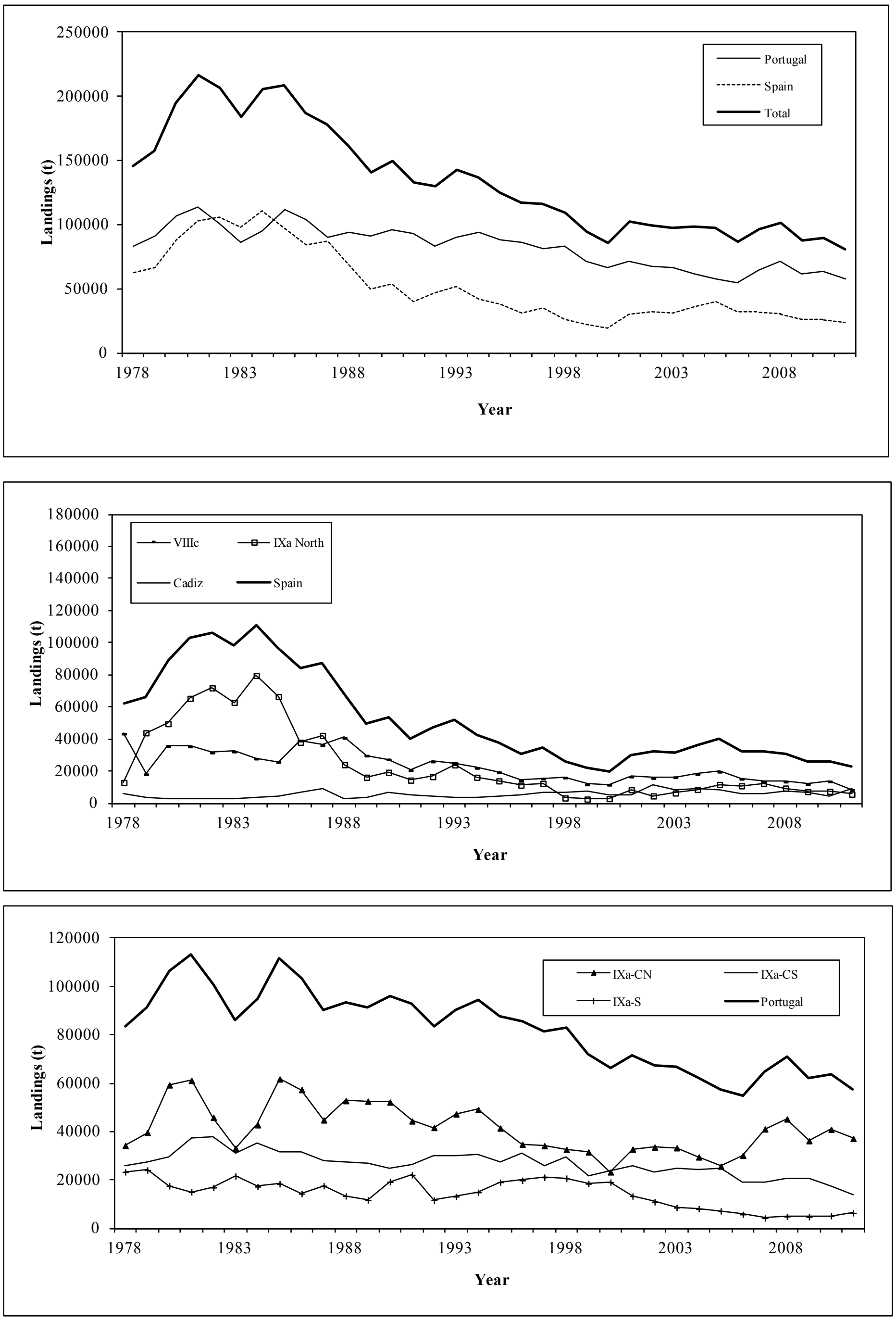
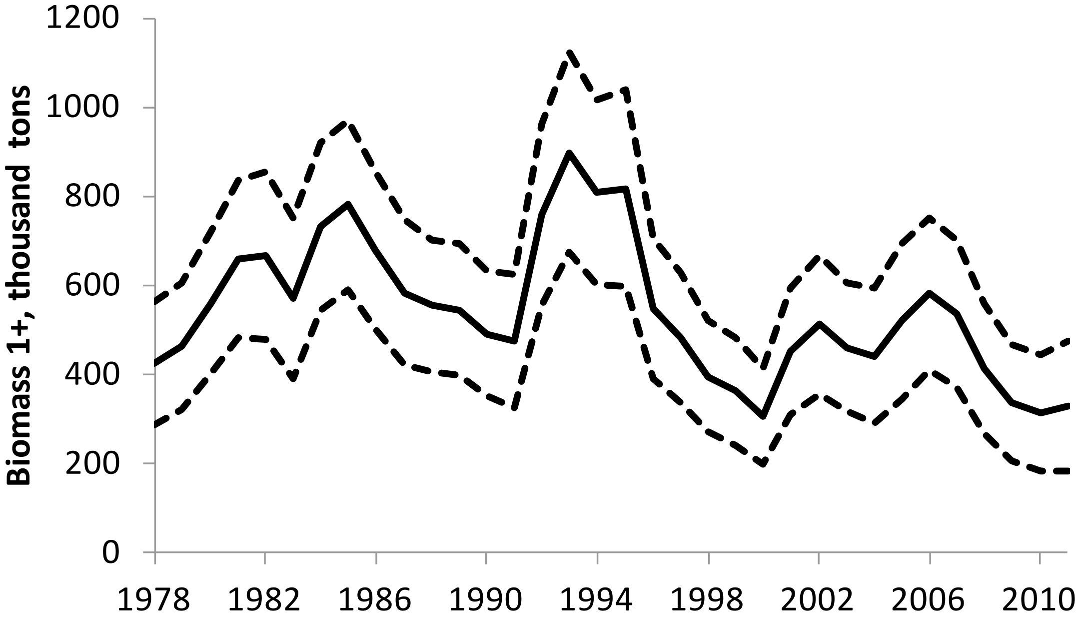
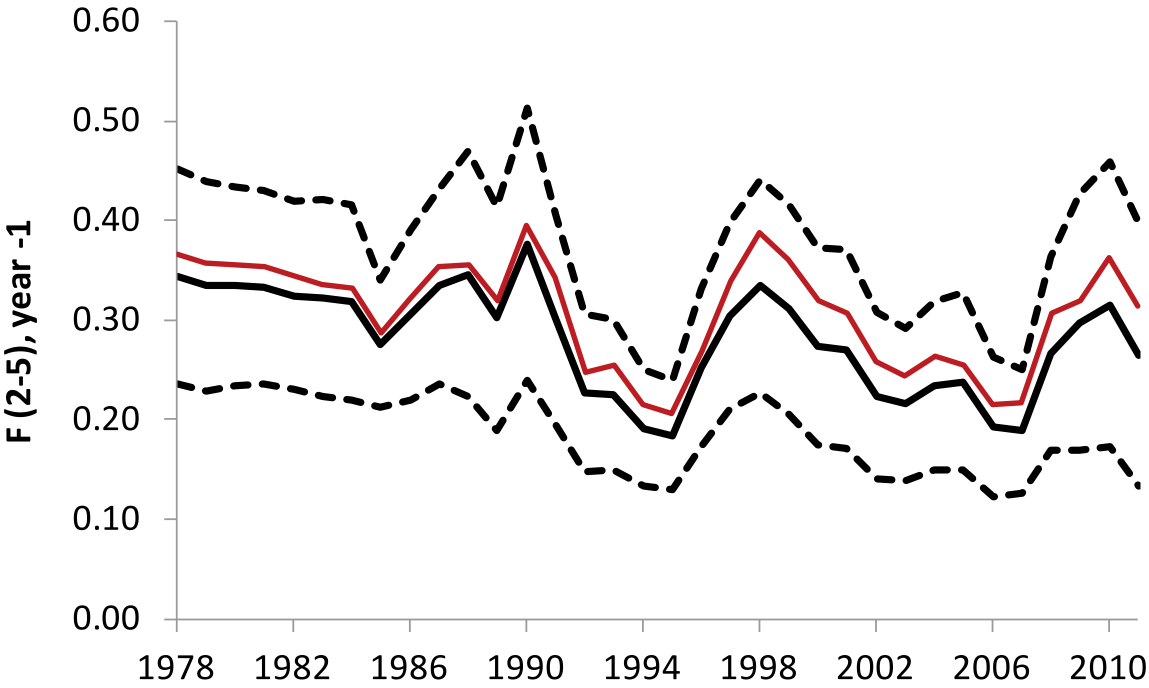


Figure 1.1 – Sardine landings in 1978 – 2011.



Biomass 1+, thousand tons
1200
1000
800
600
400
200
0
1978
1982
1986
1990
1994
1998
2002
2006
2010



F (2-5), year -1
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1978
1982
1986
1990
1994
1998
2002
2006
2010

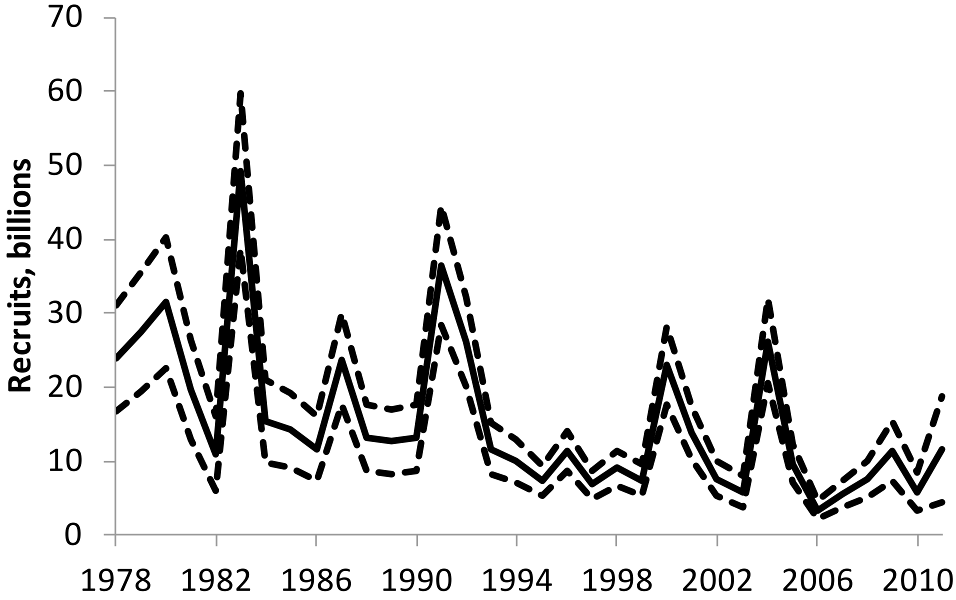


Figure 1.2. Sardine VIIIc and IXa: Historical B1+ (top), F(2-5) (middle) and recruitment (bottom) trajectories in the period 1978 – 2011 (ICES, 2012b). Dashed lines show mean values ± 2 Standard Deviations. The red line shows the corrected F(2-5) series (see footnote 1 and Table 1).

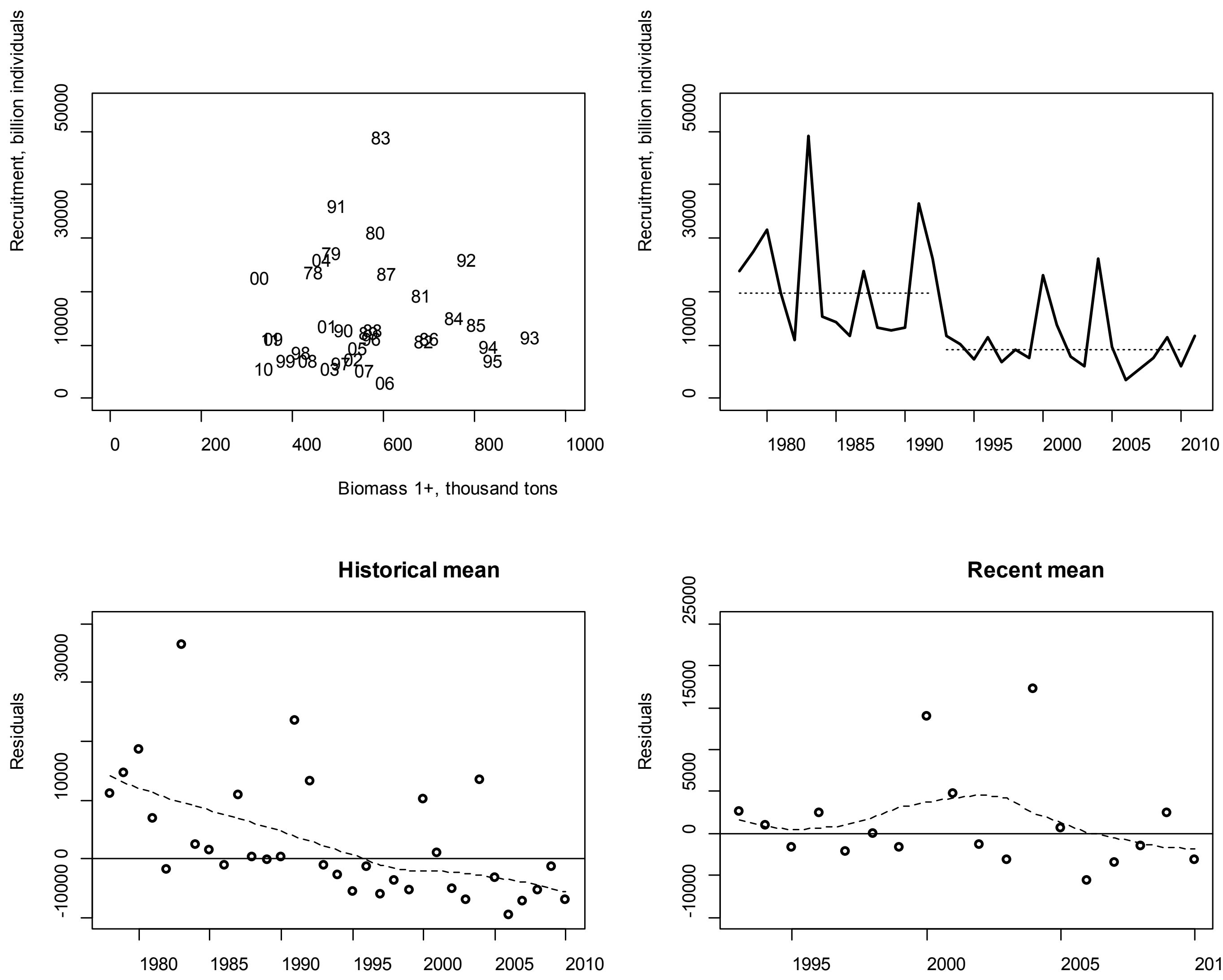


Figure 2.1 – Stock recruitment scatterplot (top left; numbers show years), historical recruitment (top right; dashed lines show geometric mean recruitment in 1978-1992 and 1993-2010 to outline periods with high and low productivity), recruitment deviations from the geometric mean of 1978-2010 (bottom left) and recruitment deviations from the geometric mean of 1993-2010 (bottom right; dashed lines are loess smoothers with span=0.75).

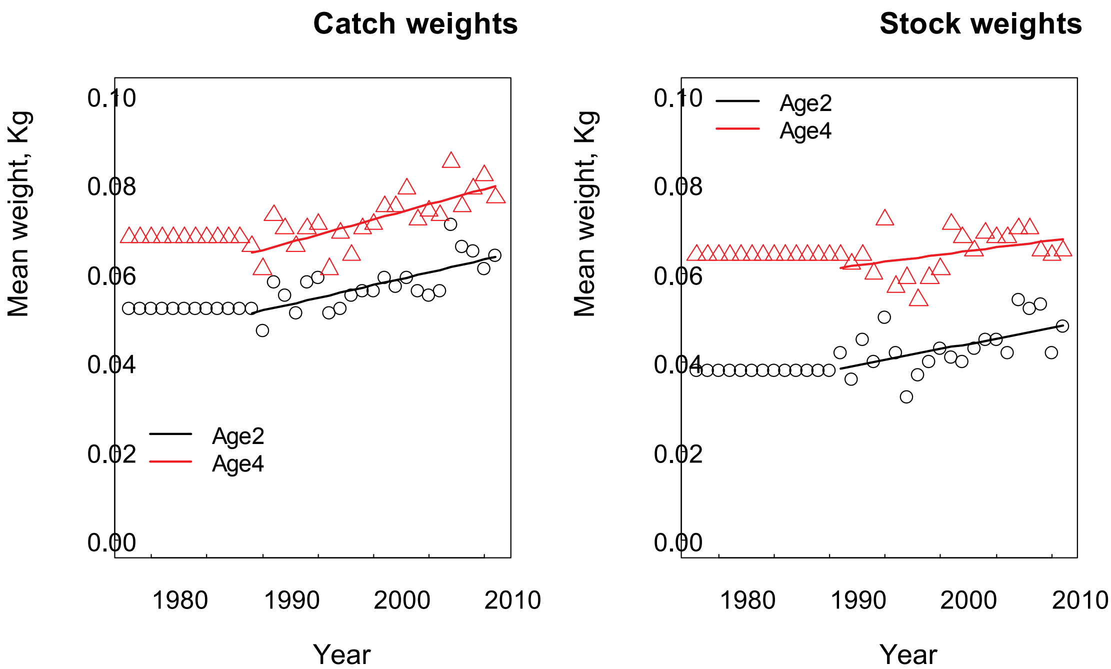


Fig 2.2 – Illustration of trends in weights-at-age. The lines are linear regressions of weight on year for each age.

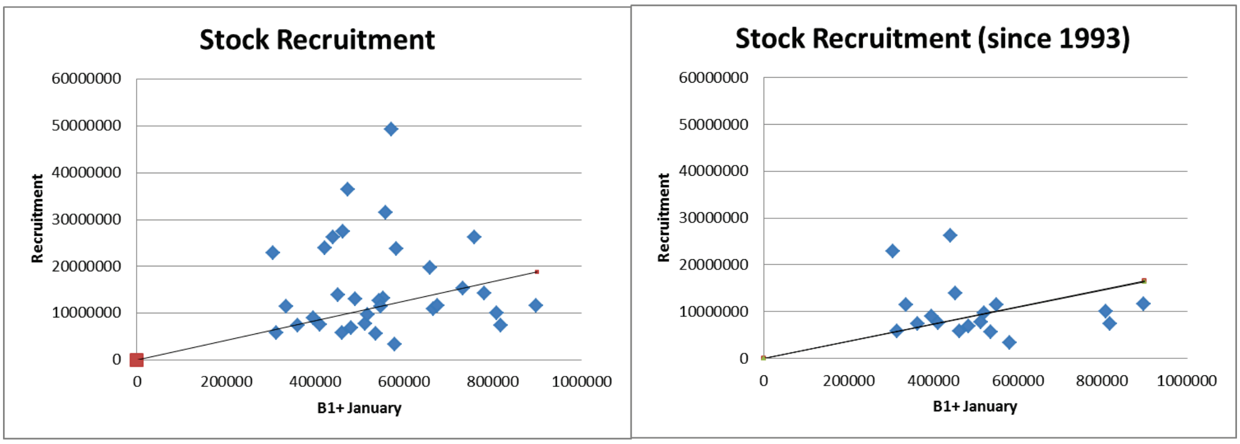


Figure 3.1 – Stock recruitment scatterplots for the periods 1978-2010 (left) and 1993-2010 (right) with the median replacement lines.

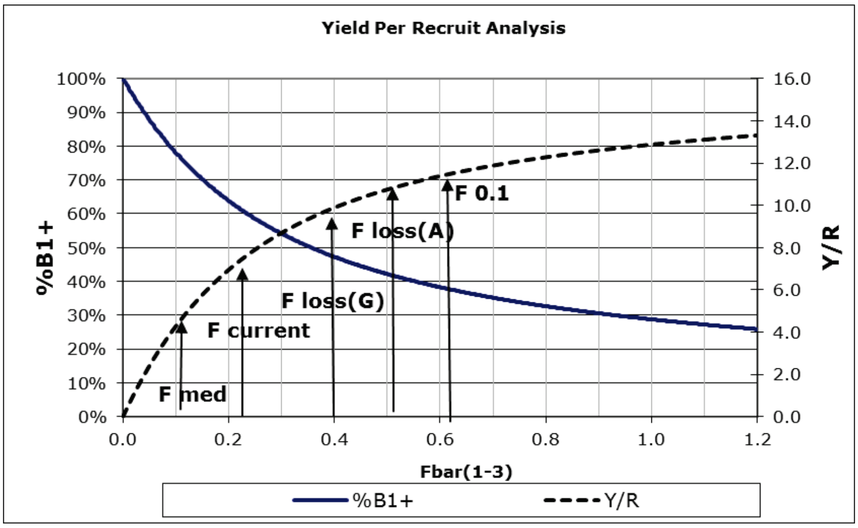


Figure 3.2 - Summary of the results of the deterministic YPR analysis with indication of Floss for the Geometric (G) and arithmetic (A) means .

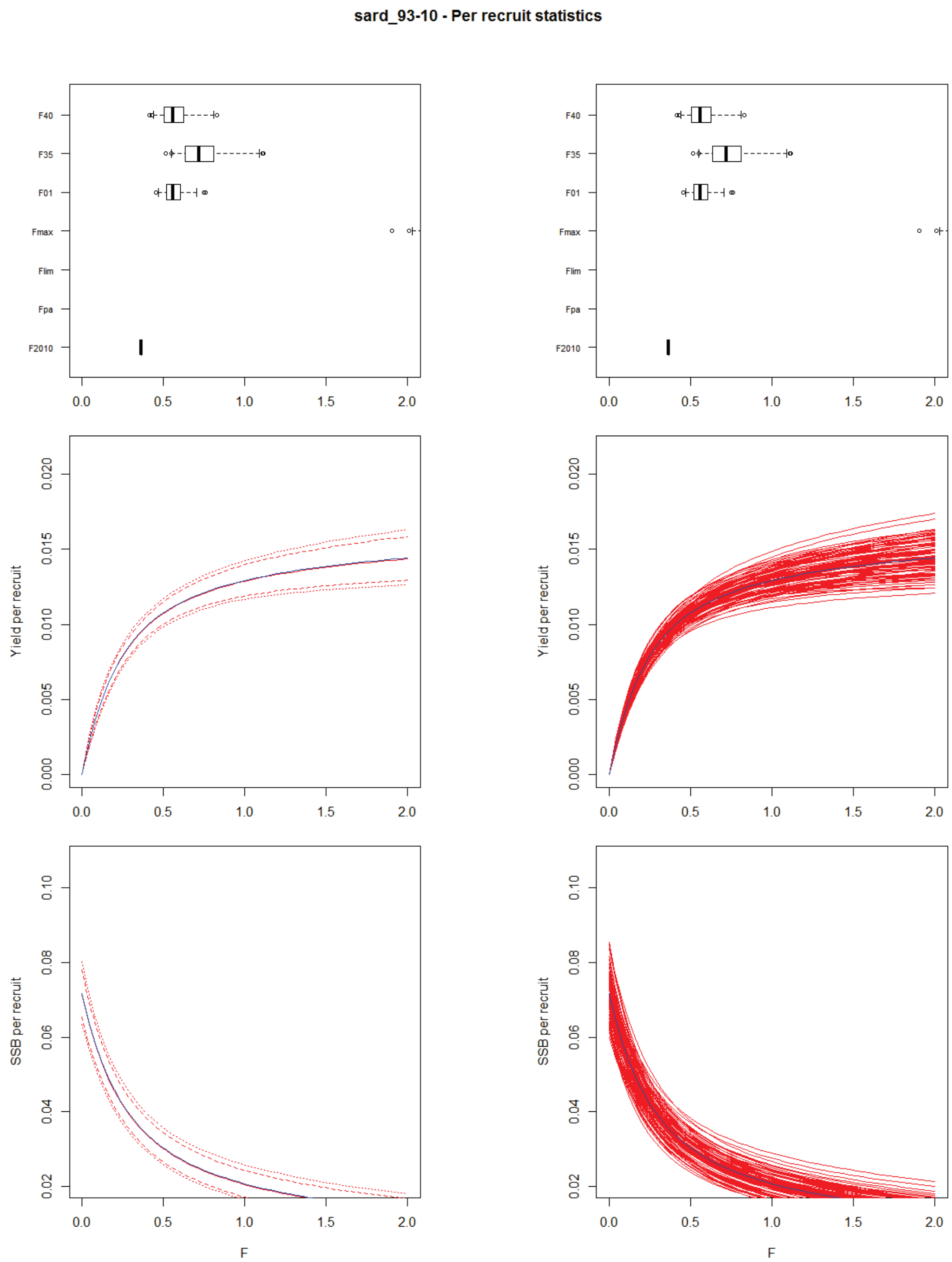


Figure 3.3 – Yield and biomass per recruit curves from plotMSY analysis.

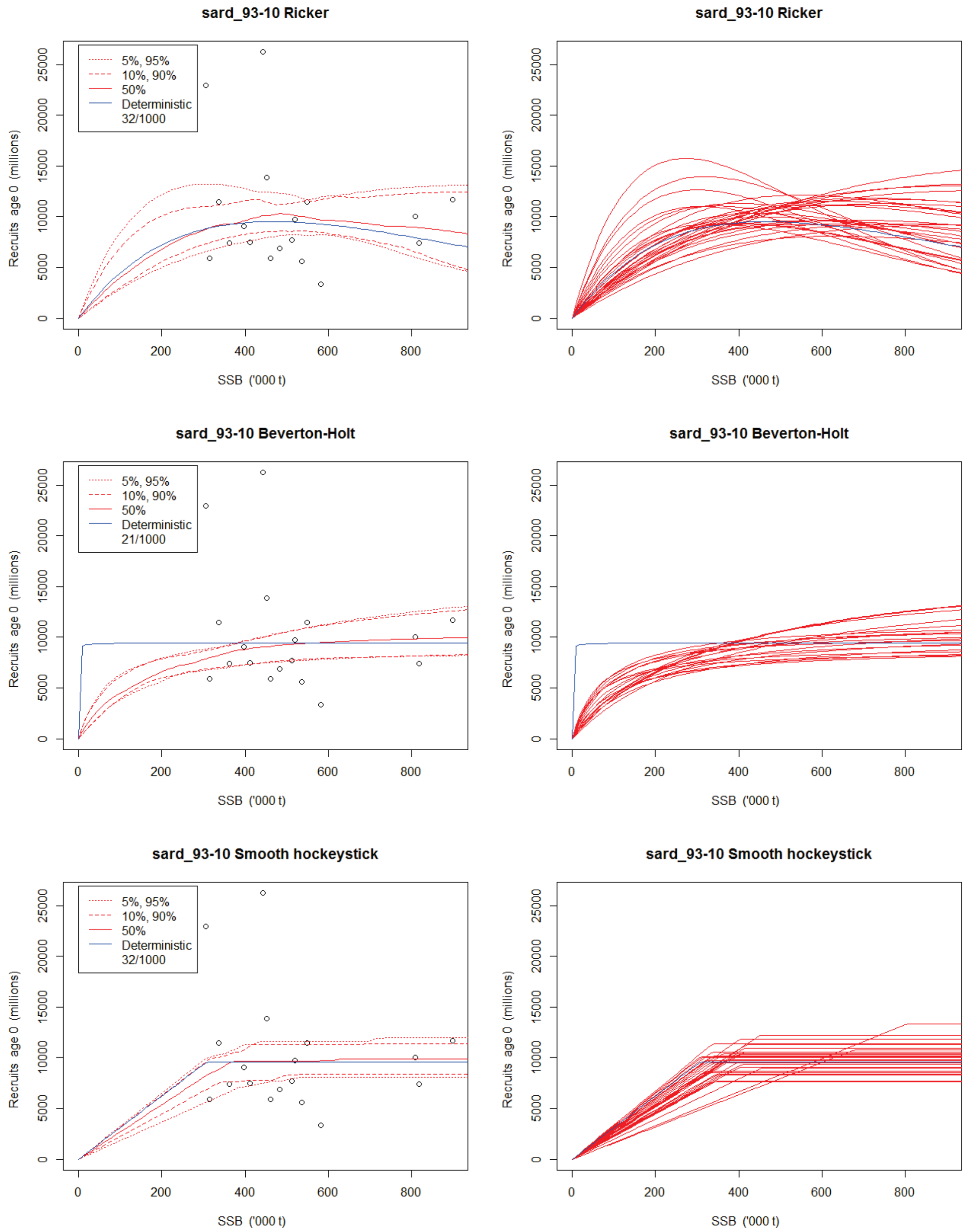


Figure 3.4 – Fit of the three common stock recruitment models to data from 1993-2010 (low recruitment scenario) in the plotMSY analysis.

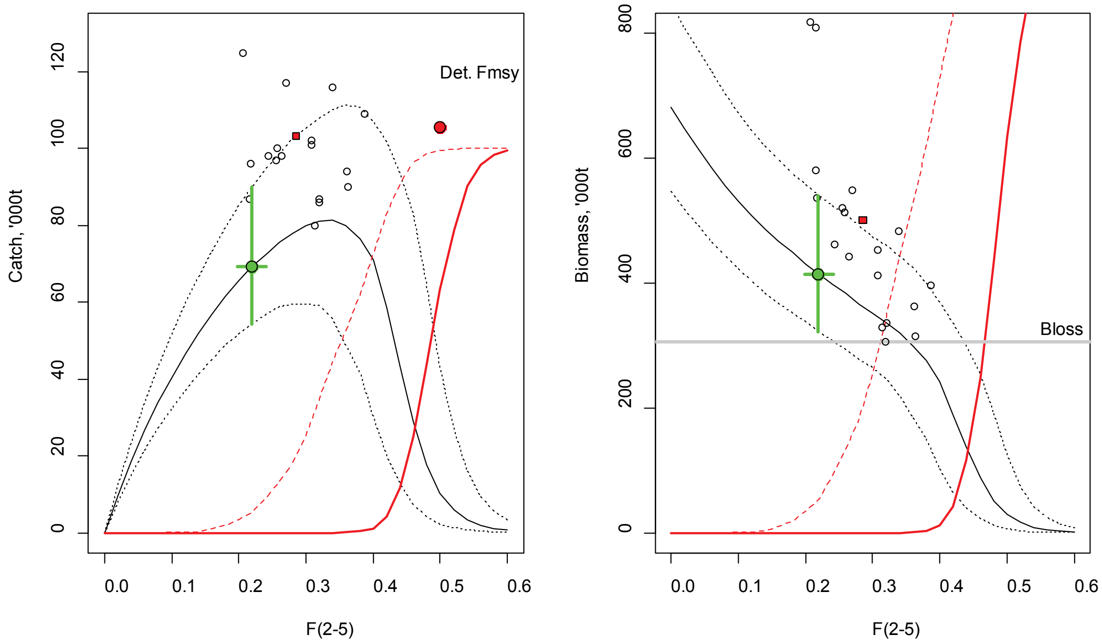


Figure 3.5- Equilibrium yield and biomass for the base case scenario (Case1a) from the stochastic YPR analysis with HCS. The continuous red line is the probability of crashing the stock. The dashed red line is the risk that B1+< Bloss. The green dot shows the fishing mortality that corresponds to a risk of B1+< Bloss lower than 5% under equilibrium conditions (F_PSY), and corresponding yield (Yield_PSY) and biomass (B1+_PSY). The green lines are 10% and 90% percentiles of the previous values. The circles are historical values of fishing mortality, catch and biomass in 1993-2010 (mean value in red). Note: risk values should be read on the y scale, with 100% risk corresponding to 100 on the catch plot and to 1000 on the biomass plot.

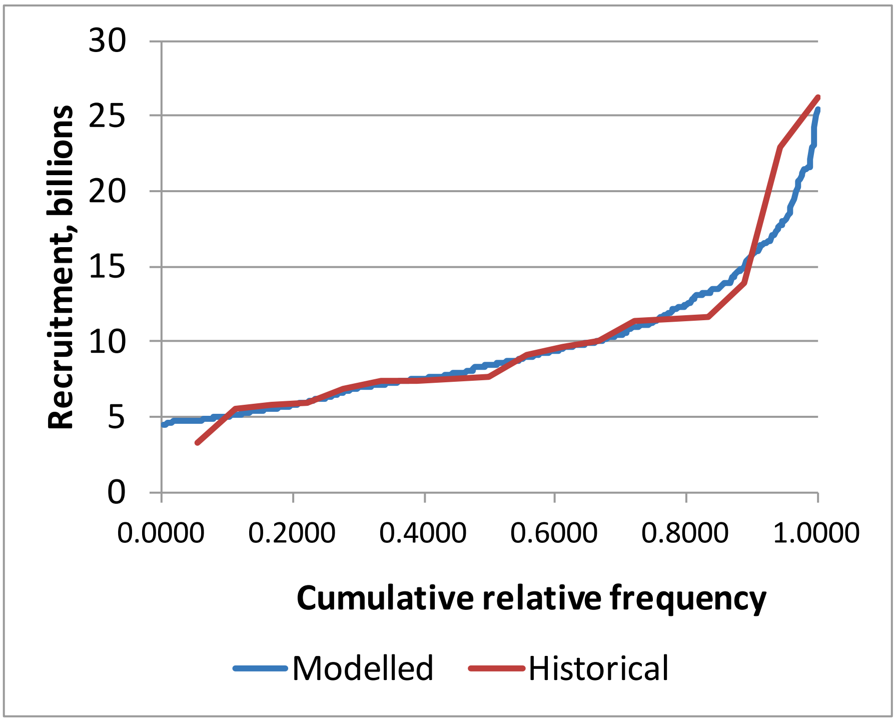


Figure 3.6 – Cumulative frequency of HCS modeled recruitments (low productivity scenario) and historical recruitments in the same period (1993-2010). Modeled recruitments are taken from 500 iterations for B1+>Bloss.

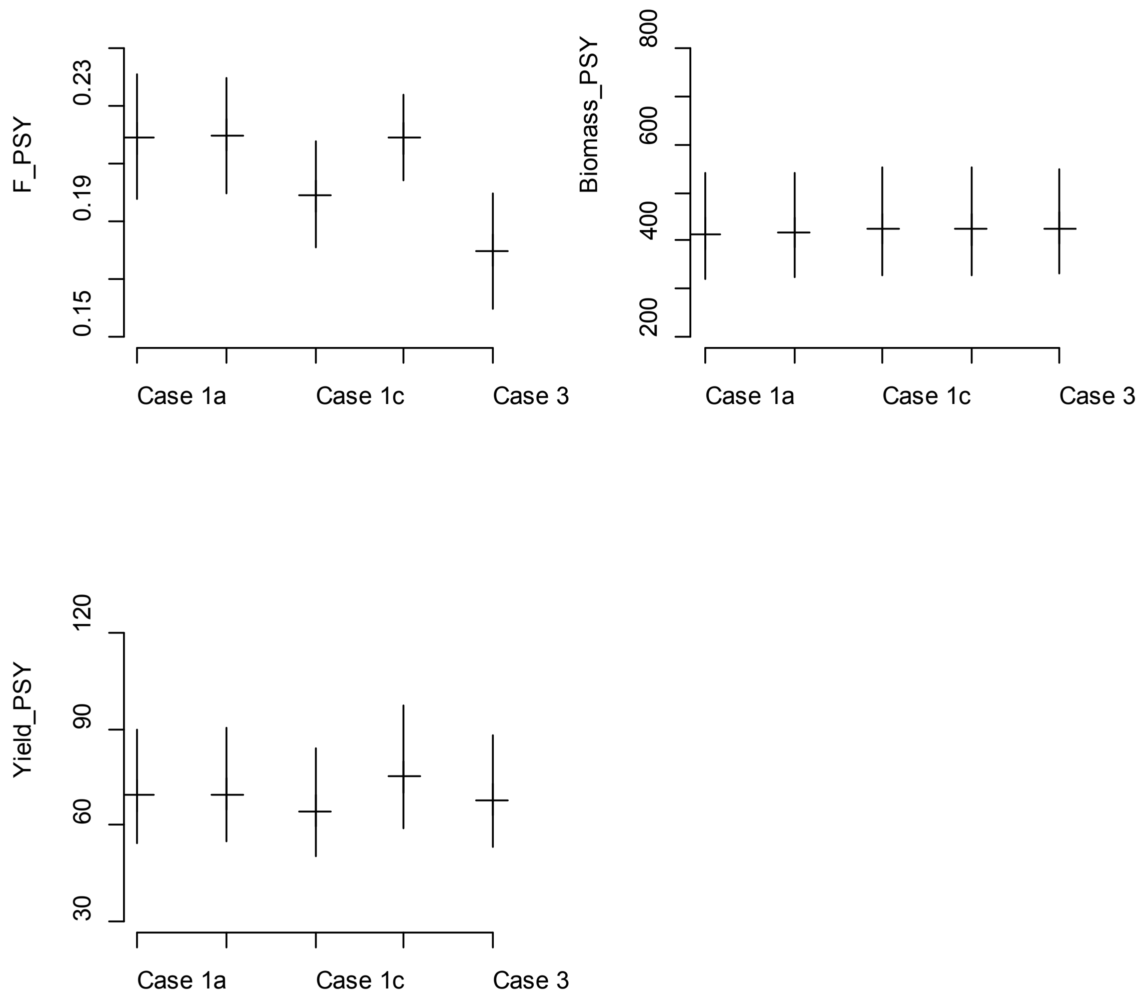


Figure 3.7 – Results of the scenarios (Cases 1-3) explored with HCS13_3. (Top left) Fishing mortality which, with high probability, keeps the stock biomass above Bloss assuming equilibrium conditions (Prob(B1+<Bloss)<5%) and corresponding biomass (Top right) and Yield (Bottom left). The 10%, 50% and 90% percentiles are shown.

ANNEX 1: SUMMARY OF THE INFORMATION AVAILABLE ON EFFECT OF ENVIRONMENTAL DRIVERS ON IBERIAN SARDINE (*Sardina pilchardus*) DYNAMICS

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Abstract

A brief summary is presented on the results of published studies looking at the effects of environmental variables, at local, regional and global scales, on the abundance and landings of sardine (*Sardina pilchardus*) in Iberian Atlantic waters. Information is also presented on the Pacific and South African sardine (*Sardinops sagax*) stocks for comparison. Results from these studies indicate varying degree of success in explaining and predicting abundance and recruitment series using empirical statistical models.

We also summarize the results of climatic and oceanographic studies in the region and examine evidence for regime shifts. Where regime shifts are proposed, we report on the periods identified as representing low (and high) productivity regimes. However, no unequivocal evidence of regime shifts has been found for the main study area. Much as in the case of fitting empirical models to fish abundance series, the perspective may change depending on which environmental or abundance time-series are considered, the length of the time series, and when the study was carried out.

Small pelagic fish such as sardine and anchovy are characterised by wide interannual fluctuations in abundance (see e.g. Lluch-Belda et al., 1989; Schwartzlose et al., 1999 for reviews). This variability has generally been attributed to environment effects on growth and survival of early life stages and, consequently, recruitment. Several mechanisms have been proposed to explain how different spatially and temporally averaged environmental variables could affect juvenile fish. Effects of the environment on adult fitness and therefore egg production, and on hatching success, have received less attention. It is not clear that recruitment variability is markedly higher in small pelagic fish than in other fish populations. However, in short-lived species, such as many small pelagic fish, recruitment assumes a more important role in population dynamics due to the small number of adult generations and hence less buffering against effects of recruitment fluctuation.

Due to the complexity of marine processes, many hypotheses are possible to explain how the environment could affect fish recruitment (or population variability generally). These range from ideas based on the properties at water column at short temporal scales (e.g. Stable Ocean Hypothesis; Lasker, 1975), meso-scale features (e.g. Optimal Environmental Window Hypothesis; Cury and Roy, 1998) and phenological processes (e.g. Match/Mismatch Hypothesis; Cushing, 1990), to theories based on ocean-scale long-term climatic modes of variability (e.g. Chavez et al., 2003). Proving or disproving any of these hypotheses requires an understanding of the underlying mechanisms. In addition, it is important to take into account the possible effect of biological and ecological factors such as the interactions with other species sharing the ecosystem (including humans).

In the case of the European sardine *Sardina pilchardus* (Waulbaum, 1792), the recruitment series for the Iberian Atlantic shows such fluctuations (Fig. 1) and, in the past, the periodic scarcity of fish, related to successive periods of poor recruitment, resulted in crises for both the fishery and the associated industries due to the socioeconomic repercussions (see Wyatt and Porteiro, 2002 for a review).

Based on the general "fish recruitment" hypothesis mentioned above, there have been several attempts to construct empirical models, using environmental variables at large and local spatial scales, and at temporal scales related to the stock spawning period, to try to explain sardine recruitment variability (e.g. Dickson et al., 1988; Guisande et al., 2001, 2004; Carrera & Porteiro, 2003; Cabanas et al, 2007; Pérez et al., 2010). These studies, summarised in Table 1, obtained mixed results in terms of their ability to predict recruitment, which we argue was due, at least in part, to data issues (e.g. short times series, autocorrelated data, collinearity between putative explanatory variables and the existence of non-linear relationships; Santos et al., 2012) and the varying ability of the methodology applied, to surmount such issues. For example, Borges et al. (2013) refer to the importance of quasi-decadal variability in climatic, oceanographic and fish time-series but where only a few decades over data are available, such cycles are difficult to detect with any certainty. In addition, in all exploited fish populations, it can be difficult to disentangle effects of fishing from those of the environment, especially when only short time-series are available.

Models based on empirical relationships between different time-series always require validation of their predictive power since, especially with short-times series, apparent relationships may be coincidental (e.g. Solow, 2002). While this obviously highlights the need for understanding of underlying mechanisms, the potential value of using environmental relationships in an otherwise unpredictable system should not be underestimated.

Environmental relationships may be strongest at the edge of a species´ distribution, where the species is also at the edge of its realised niche (Myers, 1998). Unless this range limit is due to competitive exclusion by other species, environmental conditions may be at the limits of tolerance for the species and changes in such conditions can thus be critical for survival. Nevertheless, within the distribution range, some areas are likely to be more favourable than others and, when this depends on oceanographic conditions, clearly the location and extent of optimal habitat may change over time.

Have there been regime shifts in the study area?

Environmental conditions show several different modes of variability, including random and cyclic patterns, directional change (such as global warming) and shifts from one stable state via unstable dynamics to a different stable state (i.e. "regime shifts"). Niche theory suggests that directional environmental change and regime shifts may cause a region to become unsuitable for some species, resulting in changes in species´ ranges and/or changes in community composition.

There have been several studies analysing the time series of oceanographic and climatic variables available. In northern Spain, Bode et al. (2012) summarised the results of a multidisciplinary study looking for evidence of the influence of climate change on the oceanography and plankton in the area using systematic observations collected by the IEO over several decades. Results indicated that there have been significant increases of temperature and a general decrease of precipitation and upwelling intensity, but that these changes "*were not uniform nor homogeneous through the region*". Sea water level and sea water temperature show positive trends over the time series but no regional long-term trends were apparent for the abundance of different phytoplankton groups, phytoplankton biomass or abundance and biomass of zooplankton.

It has also been proposed that meso-scale and local phenomena in this region strongly interact with large-scale climate and oceanographic processes and that this could explain the variability in the ecosystem responses identified and in the interactions between the non-living and living components of the ecosystem (Bode et al., 2012).

For instance, in Portugal, Lemos and Pires (2004) propose a weakening of the upwelling along the coast and an increase of both offshore and coastal SST since the 1940s. The increase in the SST of coastal waters was subsequently supported by another study (Lemos and Sansó, 2006) which also highlighted an increase in the stratification of coastal waters off Portugal. This warming trend (in SST) was not however homogeneous, and significant spatial differences were found within the study area for the period 1985–2008 (Relvas et al., 2009), revealing the complexity of the oceanography in the region. As was the case for the NW Iberian shelf, where the dynamics of the upwelling (Pardo et al., 2010) and their effect on biological production are not homogeneous (e.g. Pérez et al., 2010; Bode et al., 2011), the superimposition of meso-scale processes on larger-scale variability can obscure the underlying processes and hence limit our understanding of the functioning of the ecosystem in the area (Relvas et al., 2007).

Conclusion:

There is little or no unequivocal evidence of a clear regime shift, i.e. a switch between different stable system states, at least at a regional scale. When shifts have been proposed for the study region or adjacent regions (i.e. Borges et al., 2003 in western Iberian waters; Hemery et al., 2008 in the Bay of Biscay), the breaks identified in the time series do not always coincide with those identified in other studies. Much as in the case of fitting empirical models, the perspective may change depending on which time series are considered, the length of the time series, and when the study was carried out. In addition, the human predisposition to divide the world into categories sometimes leads to imposition of artificial divisions on what is in reality a continuum.

Stock recruitment relationships and reference points for other sardine stocks

Sardine species (Japanese sardine (*Sardinops melanosticus*), South African sardine (*Sardinops sagax*), etc.) are one of the main small pelagic fish resources in eastern boundary upwelling systems. These populations are valuable and highly variable, characterized for the unpredictable dynamics of recruitment.

For this reason, despite a great effort has been devoted to the study of the stock recruitment relationships in these stocks (including studies that takes into account the effect of environmental variables, etc.(Galindo Cortes *et al*., 2010, McClatchie *et al*., 2010)) results are not conclusive (Wada and Jacobson,1998; Sakuramoto, 2012) and a variety of management options have been proposed.

Several analyses carried out for the Pacific sardine (*Sardinops sagax*) have proposed relationships between the strength of the recruitment and SST (Lindegren and Checkley, 2013), upwelling (Ryckaczewski and Checkley, 2008), current strength (Maccall, 2004) and indices such as the Pacific Decadal Oscillation of basin wide scale (e.g. Zwolinski and Demer, 2012). However, McClatchie et al. (2010), in contrast to some earlier studies cited therein, found no relationship with SST.

As in the case of other sardine stocks, fluctuations in biomass and shifts in distribution of South African sardine (*Sardinops sagax*) have also been attributed to environmental drivers coupled with overfishing (e.g. Coetzee et al., 2008). For the South African Pelagic Fishery and Pacific Sardine Fishery, operational targets and decision rules are based around the outputs of age- structured models that use survey data and other information to generate estimates of 1+ biomass. In the Western Australian fisheries, the stocks are recovering from substantial declines in abundance, and the decision rules indicate that exploitation rates should not exceed 20% of the spawning biomass (Cochrane 1999; Gaughan and Leary 2005a, b).

The South Australian Sardine stock assessment considered that the recommendations of Smith et al. (2011) (bearing in mind that the yields from productive species such as sardine should be typically reduced at depletion levels below 60%) are too conservative for this stock and the 40% of unfished biomass was considered appropriate (Ward *et al.* 2012).

For the assessment of the Japanese sardine Nishida *et al.* 2007 have used three reference points: two for biomass (Bban and Blim) and one for fishing mortality (Flim); Flim sets the maximum F allowed; Blim acts as a threshold below which F decreases linearly until Bban is reached, where the fishery is closed and F becomes zero (Hurtado-Ferro *et al.,* 2010).

In other minor stocks as the South Alboran sardine (*Sardina pilchardus*), the level of exploitation is determined by analyzing the curve of yield per recruit and the calculation of biological reference points $F_{0.1}$ (FAO, 2011).

Role of sardine as a forage species in the ecosystem

There is considerable debate about whether the dynamics of marine ecosystems typically involve top-down, bottom-up or wasp-waist control. Cury *et al.* (2003) suggested that bottom-up control predominates in marine ecosystems, while top-down control plays a role in dampening ecosystem-level fluctuations and wasp-waist control is most probable in upwelling systems. A recent ecosystem model of Bay of Biscay waters (Lassalle et al., 2011) revealed that the continental shelf food web was strongly bottom-up controlled.

Sardine has been described as important in the diet of common dolphin (*Delphinus delphis*) in Portugal (Silva, 1999) and is also present in the diet of this species in Galician waters (Santos et al., in Press). It also occurs in the diet of bottlenose dolphins and harbour porpoises (Santos et al., 2007; Read et al., 2012) and is probably eaten by several other cetacean species. Sardine has been found also in the diet of tunas (Goñi et al., 2011) and of several other fish species, e.g. hake, anglerfish (Preciado et al., 2008).

Small, shoaling pelagic fish species such as sardine, have a higher energetic content than most other available prey and it is expected that a predator should normally “prefer” to eat these species, thereby maximizing its rate of energy intake – this is a basic tenet of optimal foraging theory (Charnov, 1976, Pyke et al 1977).

It has been suggested that common dolphins exhibit an apparent preference for sardine and anchovy (termed “fatty” species) (e.g. Meynier et al. 2008; Spitz et al., 2010). However, a recent analysis based on stomach contents data from stranded common dolphins in Galicia (Santos et al., In press) showed that the relationships between common dolphin diet and annual indices of sardine, hake and blue whiting abundance did not show clear evidence for selective predation on sardine. However, the authors pointed out that lack of evidence for selective predation on energy-rich sardine could be due to current low stock levels. An ongoing analysis suggested that the common dolphins diet in Portuguese continental has changed in response to changes in the pelagic fish community, particularly the decline of sardine and the increase of chub mackerel (Marçalo et al, 2013).

To be able to quantify the role of sardine as a forage species in the Iberian Atlantic ecosystem, we need an ecosystem model that would allow the inclusion of sardine, its predators, its prey and its competitors. For example, Sánchez & Olaso (2004) published an ECOPATH with Ecosim (EwE) model of the Cantabrian Sea. The model included fisheries, although marine mammals and seabirds were not included. More recently, Lassalle et al. (2011, 2012) developed an EwE model for the Bay of Biscay to examine the likely effect of changes in fishing pressure on top predator populations. Creation of such a model for the Iberian Atlantic ecosystem would permit the evaluation of the ecosystem effects of fishing for sardine and any proposed regulatory measures.

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Regimes and stock-recruitment relationships in Japanese sardine (Sardinops melanostictus), 1951-1995. Tokio Wada, Larry D Jacobson

Figure 1. *Recruitment series for the Iberian sardine stock: two separate periods are proposed (marked with the horizontal coloured lines) before and after 1993.*

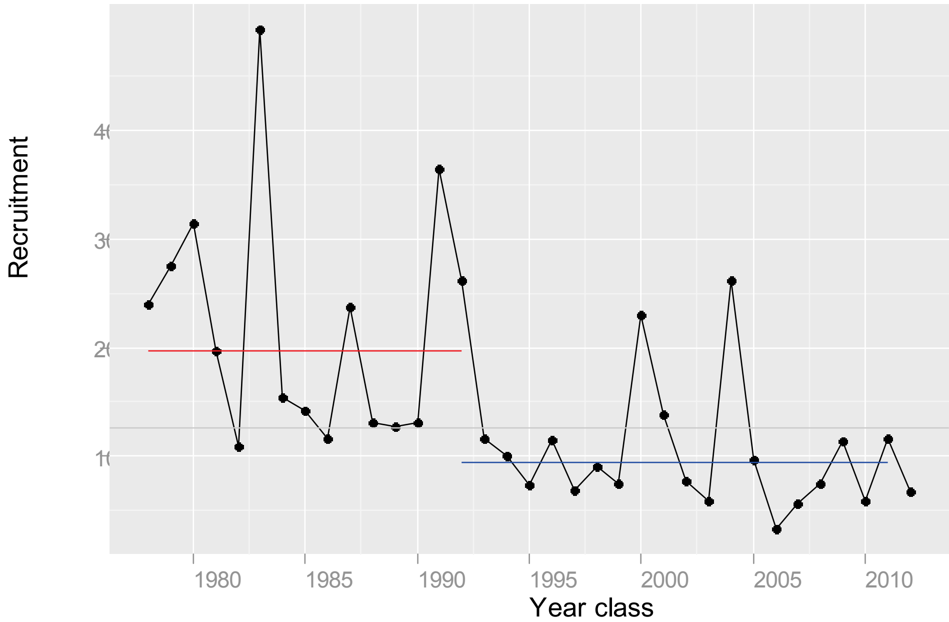


Table 1. *Examples of empirical relationships between Iberian sardine abundance and environmental conditions.*

Scale	Response	Explanatory	Method	Results	Reference
Global and local	Landings of juvenile fish in Vigo (1906-1980)	Sunspot cycle length and the averaged number of sunspots and Ekman transport	Correlations on MC simulations (to avoid autocorrelation)	Sun activity influences water transport that in turn influences R	Guisande et al. 2004
Regional and local	Landings of adult and juvenile fish in Vigo (1906-1980)	Water column stability in February, offshore water transport in March–April, upwelling intensity in the preceding year, and NAO	Definition of an OEW with the explanatory variables using 10-year moving average	Relationships with all the variables (added together to define the OEW)	Guisande et al. 2004
Regional	Sardine landings in IXa (1950-1984)	Average April upwelling index at Porto over the preceding 3 years	Correlation	Relationship highest for the April upwelling index and inverse to catches	Dickson et al. 1988
Regional and local	Portuguese sardine landings (1946-1991)	Wind conditions and NAO	Standard correlation and spectral methods	Periodicity (15 ys) in catch series. Relationships with NAO and wind patterns. Two periods proposed (before and after 1970s)	Borges et al. 2003
Regional and local	Landings of juveniles in Vigo (1980-2000)	NAO winter, upwelling intensity, turbulence, water column stability, larval offshore transport,) and adult abundance	Linear and non-linear regression	Ekman transport and NAO winter	Guisande et al. 2001
Local	R (1976–1998)	Upwelling variability	Linear correlations	For 1987–1992, R at age 0 is positively correlated with the April–September upwelling index. The significant relationship disappears after 1993	Santos et al., 2001
Local	SSB, R and R/SSB (1978–2006)	upwelling index and SST	Multi-oscillatory system approach	Two orbits of stability	Solari et al. 2010
Local	Sardine landings in VIII (1965-2006)	Net Production (calculated using the upwelling index)	Correlations	Explained as decreased upwelling in NW Spain	Pérez et al. 2010

				affects early life stages survival	
Regional and local	R (1978-2007)	Northern hemisphere atmospheric indexes and Ekman transport and wind data	Application of machine learning techniques	Predicted years of low, medium and high R related to mean N Atlantic SST and meridional momentum fluxes across offshore banks	Fernandes et al. 2012 (FACTS report)
Global, regional and local	R and SSB (1978-2011)	Sunspots, northern hemisphere atmospheric indexes, SST, wind strength and upwelling index	Time series decomposition (spectral analysis, GAMs, GAMMs)	Trends in R related to trends in number of sun spots, NAO autumn, winter wind strength and upwelling index Variation around the trend in sardine R related to SST	Santos et al. 2012

Annex 2: Summary of stock-recruitment models fit to sardine using package FLCore 2.4. Model formulae: Ricker model: alfa*B*exp(-beta*b); Beverton-Holt: alfa*B/(beta+B); Segreg: ifelse(c(B) <= beta, alfa * B, alfa * beta. Models were fit to biomass in million tons and recruitment in billion individuals. Commnets on autocorrelation, trends and minimization are based on a graphical analysis.

	Alfa		Beta		Rho			Derived quantities				Minimization			
MODEL	**Value**	**Std.Error**	**Value**	**Std.Error**	**Value**	**Std.Error**	**AICc**	**Rmax (billions)**	**B1+ at Rmax (million t)**	**Autocorrelation**	**Trend in residuals**	**Alfa**	**Beta**	**Rho**	**Comments**
Whole period: 1978-2010															
Ricker	59.4	23.7	1.62	0.70			- 10.5	96.279	0.042	Y +	Y -	Clear	Clear		Plausible
Berverton-Holt	15.4	7.1	0.10	0.28			- 10.2			Y +	Y -	Clear	Clear		Density-dependant phase well below observed data
Segmented regression	30.4	3.4	0.44	0.02			- 10.5	13.456	0.442	Y +	Y -	Unclear	Clear		Plausible; breakpoint well above Bloss
Recent period: 1993-2010															
Ricker	55.3	20.7	2.14	0.70			- 10.9	7.006	0.468	N	N	Clear	Clear		Historical data on the right descending limb
Berverton-Holt	6.5	2.0	-0.13	0.09			- 11.5			N	N	Clear	Clear		Not plausible
Segmented regression	31.5	774.9	0.29	7.05			- 10.6	9.029	0.287	N	N	Unclear	Unclear		Plausible
Autoregressive, whole period (1978-2010)															
Ricker Autoregressive(1)	227.3	165.1	4.13	1.27	0.81	0.09	- 18.3	4.820	0.242	Y -	N	Clear	Clear	No min	Historical data on the right descending limb
Berverton-Holt Autoregressive(1)	7.1	2.7	-0.21	0.07	0.76	0.09	- 17.0			Y -	N	Clear	Clear	No min	Not plausible
With evironmental parameters															
Ricker 1978-2011; alfa affected by SST	754.2	282.9	2.10	0.59	-0.06	0.00	- 18.5			Y + (weak)	Y -	Clear	Clear	No min	Plausible
Ricker 1994-2011; alfa affected by SST	558.9	272.4	2.98	0.72	-0.05	0.00	- 11.4			Y + (weak)	Y -	Clear	Clear	No min	Plausible

Annex A.4 Data Issues

Annex 4.1 Stock Data Problems Relevant to Data Collection – WGHANSA

Stock	Data Problem	How to be addressed in	By who[1]
Stock name	***Data problem identification***	***Description of data problem*** ***and recommend solution***	***Who should take care of the recommended solution and who should be notified on this data issue.***
Anchovy in IXa South.	Spanish survey on anchovy in Cadiz (DEPM BOCADEVA) which is one of the pillars for the trend assessment are not guarantee by Spanish administration and Not funded within the DCF.	These survey need to be funded by the EC through the DCF	*PGCCDBS, and RCM SCICOM Steering Group on Ecosystem Surveys, Science and Technology (SSGESST)*

[1] Recommendations on surveys for be addressed by the SCICOM Steering Group on Ecosystem Surveys, Science and Technology (SSGESST)

Stock	Data Problem	How to be addressed in	By who[1]
Sardine in VIIIc and IXa ***Anchovy in IXa.***	Both for sardine and anchovy in the area, an indication of the strength of incoming year classes would improve the advice on management.	The WG recommends DCR to economically support an autumn acoustic survey for provision of recruitment indices for sardine and anchovy. This could be addressed by a coordinated survey between IPIMAR and IEO, covering the NW of Portugal and Cadiz where major recruitment of sardine and anchovy occur.	*SCICOM Steering Group on Ecosystem Surveys, Science and Technology (SSGESST)* *PGCCDBS should support the idea of such a Survey and communicate to RCM and to relevant bodies accordingly* *The same idea was recommended by WGHANSA and WGACEGG since 2009*
Sardine in VIIIc and IXa ***Anchovy in IXa.*** ***Anchovy and Sardine in VIII***	In 2012, the PELACUS survey took place for first time on board R/V Miguel Oliver instead of R/V Thalassa.	The WG recommends an intercalibration between the Spanish, Portuguese and French vessels to ensure the correct use of the joint biomass index for sardine in the assessment along the time series and compatibility between surveys results for anchovy.	*To SCICOM Steering Group on Ecosystem Surveys, Science and Technology (SSGESST) and WGACEGGs* *And to IEO and IPMA*
Anchovy in IXa	There is a need to improve the age reading methodology, specially on the southern areas of the stock.	The WG recommends an otolith exchange between Spain and Portugal	***PGCCDBS***

Stock	Data Problem	How to be addressed in	By who[1]
Sardine in subarea VII	The WG noticed that there is no monitoring program of sardine catches, age lenth keys, lenth distribution, discards and effort data in subarea VII. This hampers assessment and provision of advice for this region	The WG demands that a Monitoring of sardine (catches, lenth, ALK, effort and discards) in subarea VII is requested and assured by countries involved in the fishery.	*PGCCDBS should support the idea and pass to RCM for inclusion in the DCF.*
Sardine in VIII & IXa	Due to low sardine abundance in the Galician and Cantabrian areas, collaboration between the R/V Miguel Oliver and commercial vessels will increase considerably the reliability of the abundance index estimate, particularly in terms of echoe determination	The WG recommends the continuation through DCR or national fundings.	*SCICOM Steering Group on Ecosystem Surveys, Science and Technology (SSGESST)* *PGCCDBS*
Sardine in subarea VIIIabd and VII	The WG noticed that there is a need for surveys in VII on small pelagics.	Design and support economically such a survey	*SCICOM Steering Group on Ecosystem Surveys, Science and Technology (SSGESST)*

Stock	Data Problem	How to be addressed in	By who[1]
Anchovy in Subarea VIII	Incorporation of JUVENA in the provision of advice. For the future management of this stock, a continuation of surveys to monitor anchovy juveniles in autumn is mandatory in order to provide indications of the incoming recruitment for the next year.	*DCR to economically support the continuation of the acoustic assessment of juveniles in the Bay of Biscay (JUVENA survey)*	*SCICOM Steering Group on Ecosystem Surveys, Science and Technology (SSGESST)* *PGCCDBS should support the idea of continuation of such a Survey and communicate to RCM and to relevant bodies accordingly for its inclusion in DCF.*
Anchovy in Subarea VIII	Since 2007, the collaboration between the R/V Thalassa and commercial vessels has increased considerably the reliability of the abundance index estimate, particularly in terms of echoe determination	The WG recommends the continuation through DCR or national fundings.	*SCICOM Steering Group on Ecosystem Surveys, Science and Technology (SSGESST)* *PGCCDBS should support the idea of continuation of such a Survey and communicate to RCM and to relevant bodies accordingly for its inclusion in DCF.*

A.4.2 data needs from ICES_for WGHANSA.xlsx

code	name	ecoregion	EG	Assessment Type	Assessment Model	**Discards**	**Stock category in 2012**	Target stock category	Length freq.	**ALKs**
ane-bisc	Anchovy in Subarea VIII (Bay of Biscay)	Bay of Biscay and Iberian seas	wghansa	Analytic						
					Bayesian	Not included, cor	1	1	Yes, quarterly	Yes, quarterly
ane-pore	Anchovy in Division IXa	Bay of Biscay and Iberian seas	wghansa	Trends survey						
					-	Not included, cor	5.2.0	3.1	Yes, quarterly	Yes, quarterly
hom-soth	Horse mackerel (T. trachurus) in Division IXa (Southern stock)	Bay of Biscay and Iberian seas	wghansa	Analytic			1	1		
					AMISH	Not included, cor			Yes, quarterly	Yes, quarterly
jaa-10	Blue jack mackerel (T. picturatus) in Subdivision Xa2 (Azores)	Bay of Biscay and Iberian seas	wghansa	Trends cpue/lpue			5.2.0	4		
					-	Included				
san-scow	Sandeel in Division VIa	Celtic Seas	secr	Catch only			6	6		
					-	Not available			Not used and no need t	Not used and no need to be collect
sar-soth	Sardine in Divisions VIIIc and IXa	Bay of Biscay and Iberian seas	wghansa	Analytic			1	1		
					SS3	Not included, cor			Yes, quarterly	Yes, quarterly
sar-bisc	Sardine in Divisions VIIIabd and subarea VII	Bay of Biscay and Iberian seas	wghansa	Trends survey/cohort analysis			Channel /3 Bay	3		
					-	Not included, cor			Yes, quarterly for the B	Yes, quarterly for the Bay of Biscay

code	name	Growth information	Weight	Sex ratio	Maturity	Fecundity	Landings
ane-bisc	Anchovy in Subarea VIII (Bay of Biscay)	yes	Yes, quarterly	Yes, only from surveys	Yes, only from surveys	Yes, triennially	Yes, monthly
ane-pore	Anchovy in Division IXa	Yes, is needed	Yes, quarterly	Yes, only from surveys	Yes	Yes, triennially	Yes, monthly
hom-soth	Horse mackerel (T. trachurus) in Division IXa (Southern stock)	Yes	Yes, quarterly	Yes, only from surveys	Yes, only from surveys	Yes, triennially	Yes, monthly
jaa-10	Blue jack mackerel (T. picturatus) in Subdivision Xa2 (Azores)	#¿NOMBRE?					
san-scow	Sandeel in Division VIa	Not used and no r	Yes	Not used and no need to be collected, for the time being	Not used and no need to be collected, for the time bei	Not used and n	Yes, annually
sar-soth	Sardine in Divisions VIIIc and IXa	yes	Yes, quarterly	Yes, only from surveys	Yes, only from surveys	Yes, triennially	Yes, monthly
sar-bisc	Sardine in Divisions VIIIabd and subarea VII	Not used and no r	Yes, quarterly	Yes, only from surveys	Yes, only from surveys	Yes, triennially	Yes, monthly

code	name	Discards	Effort	Commercial tuning fleets	Available Fisheries independent surveys
ane-bisc	Anchovy in Subarea VIII (Bay of Biscay)	Discards information is relevant for monitoring proposes, although r	Not needed for	None	Yes
ane-pore	Anchovy in Division IXa	Discards information is relevant for monitoring proposes, although r	Yes, quarterly	None	Yes
hom-soth	Horse mackerel (T. trachurus) in Division IXa (Southern stock)	Discards information is relevant for monitoring proposes, although n	ot used in the a	None	Yes
jaa-10	Blue jack mackerel (T. picturatus) in Subdivision Xa2 (Azores)				
san-scow	Sandeel in Division VIa	Discards information is relevant for monitoring proposes, although r	Not used and n	Not used	No
sar-soth	Sardine in Divisions VIIIc and IXa	Discards information is relevant for monitoring proposes, although r	Not needed for	None	Yes
sar-bisc	Sardine in Divisions VIIIabd and subarea VII	Discards information is relevant for monitoring proposes, although r	Not used currei	None	Time series of the current surveys is too short

code	name	Surveys ID	Short-term data needs	Other comments
ane-bisc	Anchovy in Subarea VIII (Bay of Biscay)	BIOMAN; PELGAS; JUVENA	Incorporation of JUVENA in the provision of advice	He have added JUVENA acoustic survey on juveniles started in 2003 and supported by WGACEGGs and in WKPELA2013
ane-pore	Anchovy in Division IXa	BOCADEVA; ECOCÁDIZ; PELACUS-Q2; PELAGO; SAR; ECOCADIZ-RECLUTAS	Given that PELAGO+PELACUS are well established, now the	He have added PELAGO acoustic and ECOCADIZ RECLUTAS surveys. There is a need to improve the age reading methodology
hom-soth	Horse mackerel (T. trachurus) in Division IXa (Southern stock)	combined PtGFS-WIBTS-Q4 and SpGCF-WIBTS-Q4	Assure the countinuity of the Spanish and Portuguese bottor	if the triennal depm become to be an index reliable it could be incorporate in assessment
jaa-10	Blue jack mackerel (T. picturatus) in Subdivision Xa2 (Azores)	-		
san-scow	Sandeel in Division VIa	-		
sar-soth	Sardine in Divisions VIIIc and IXa	PELACUS-Q2; PELAGO; SP and PT DEPM joint surveys	Given that PELAGO+PELACUS and DEPM joint surveys are we	Intercalibration of Spanish and Portuguese acoustic surveys is needed
sar-bisc	Sardine in Divisions VIIIabd and subarea VII	PELGAS; BIOMAN & Trienial DEPM	Survey indices in area VII (spring surveys). Age-lenght key an	He have added the triennial DEPM survey in VIIIabd started in 2011. There is a mandatory need for time series of data from the VII area and monitoring.

Stock	Code	RAC(s)	RAC - contact	ICES EG	ICES EG chair	Benchmark in 2014	Stock cat
Anchovy in Division IXa	ane-pore	SWW RAC		WGHANSA	Andres Uriarte	NO	5
Sardine in Divisions VIIIc and IXa	sar-soth	SWWRAC		WGHANSA	Andres Uriarte	No	1
Sardine in Divisions VIIIabd and subarea VII	Sar-bisc	SWWRAC		WGHANSA	Andres Uriarte	No	na
Anchovy in Subarea VIII	ane-bisc	SWWRAC		WGHANSA	Andres Uriarte	No	1
Horse Mackerel in Division IXa (Southern hor	hom-south	SWWRAC		WGHANSA	Andres Uriarte	No	1
Blue jack mackerel (Trachurus picturatus) in S	jaa-10	SWWRAC		WGHANSA	Andres Uriarte	No	5

DDRAC table for WGHANSA.xlsx

Include the main data deficiencies of the parameters below, and identify the responsible entity (i.e. scientists, industry, national
After filling the table, mark each cell with a colour cod of the relevance of the data deficiency, according to the following:

Imparing the current assessment/ advice.		Minor issue. Could be resolved easally

Assessment model	Stock ID	Sampling	Landings	Discards	Effort / CPUE	Others	Comments
Trend based assessment	Separation between IXaS and IXaC+IXaN	Age determination (scientist)		Support information about discards (stakeholders+ National administration)		Support of the continuation of PELAGO /ECOCADIZ /BOCADEVA surveys (EC-DCMAP+ National Administration)	
Stock Synthesis	Boundary limits and connection between stocks and areas (scientist)			Support information about discards (stakeholders+ National administration)			
Trend based assessment	Separation between VII and VIII? (scientist)	Length and age sampling in the VII subdivision (EU DCMAP)		Discard data in the VII subdivision (Stakeholders + National Administration)		Information about preference of sardine *vs* other target species in the VII area.	
Bayesian two-stage biomass-based model (BBM)				Support information about discards (stakeholders+ National administration)		The Wg aknowledges and thanks SWRAC for collecting the catches, the vessels and prices on anchovy (keep doing, please)	
AMISH (Assessment Method for the Ibero-Atlantic Stock of Horse-Mackerel).	separation between IXaS and IxaC+IXaN in Portuguese waters and IXa N and IXaS in Spanish waters			Support information about discards (stakeholders+ National administration)			
Trend based assessment				Support information about discards (stakeholders+ National administration)		Support of surveys (National Administration)	

Annex A.5 – Stock Annexes

5.1 Stock Annex – Bay of Biscay Anchovy (Subarea VIII)

Quality Handbook **Annex:A.5.1**

Stock specific documentation of standard assessment procedures used by ICES

Stock: Bay of Biscay Anchovy (Subarea VIII)

Working Group: WGANSA (working group on the assessment of anchovy and sardine)

Date: 15th to 20th of June, 2009

Revised at: WGANSA2009, WKSHORT2009 and WGANSA2010

Authors by alphabetic order: E. Duhamel, L. Ibaibarriaga, J. Massé, L. Pawlowski, M. Santos and A. Uriarte.

A. General

A.1. Stock definition

Anchovy (*Engrulis encrasicolus, L*) stock in Subarea VIII (Bay of Biscay) is considered to be isolated from a small population in the English Channel and from the population in the area IXa. No subpopulations have been defined, although morfometrics and meristic studies suggest some heterogeneity at least in morphotipes (*Prouzet and Metuzals, 1994*; *Junquera and Perez-Gandaras, 1993*). Some genetic heterogeneity based on proteins allocime loci have been found between the Garonne spawning regions and southern regions in the Bay of Biscay (Adour and Cantabrian shores) (*Sanz et al., 2008*). Nevertheless, the evident inter connection of fisheries and rather homogenous recruitment pulses occurring in the Bay of Biscay lead ICES to consider that the anchovy in this area should be dealt as a single stock for assessment and management (ICES 2007).

A.2. Fishery

The fisheries were closed since June 2006 to December 2009 due to poor condition of the stock. It was reopened in January 2010 with a TAC of 7,000t. The fisheries for anchovy are targeted by purse-seiners and pelagic trawlers. The Spanish and French fleets fishing for anchovy in Subarea VIII are spatially and temporally quite well separated. The Spanish fleet (purse seine fleet) operates mainly in Divisions VIIIc and VIIIb in spring, while the French fleet (mainly pelagic trawlers) operates in Division VIIIa in summer and autumn and in Division VIIIb in winter and summer. A small fleet of French purse seiners operates in the South of the Bay of Biscay (VIIIb) in spring and in the North (VIIIa) during the autumn. An overview of the history of the fishery until the mid nineties and its spatial behaviour is found in Junquera (1986) and Uriarte *et al.* (1996) and for more recent perspective see ICES 2007 & 2008 or STECF 2008 for the international fishery and Uriarte *et al.* (2008) Villamor *et al.* (2008) for the Spanish fishery and Duhamel (2004) and Vermard *et al.* (2008) for the French pelagic trawlers. A recent updated information (2009) provided by the SWW RAC shows a 18% decrease in the fleet size operating on anchovy since the closure of the fishery (2005). This decrease is much more important for the pelagic trawlers' fleet (-39%) than for the purse seiners (-11%). Since the fishery closure, the fleets have redeployed their effort mainly towards other small pelagic species (57%) and tunas (29%) (Table A.2.2).

Table A.2.1: Evolution of the French and Spanish fleets on anchovy in Sub-area VIII. Fishery closed in 2006, 2007 and 2008. Units: numbers of boats.

	France				Spain *	
Year	**P. seiner**	**P. trawl**		**Total**	**P. seiner**	**Total**
1960	-	-			571	571
1972	-	-			492	492
1976	-	-			354	354
1980	-	-			293	293
1984	-	-			306	306
1987	-	-			282	282
1988	-	-			278	278
1989	18	6	(1,2)	24	215	239
1990	25	48	(1,2)	73	266	339
1991	19	53	(1,2)	72	250	322
1992	21	85	(1,2)	106	244	350
1993	34	108	(1,2)	142	253	395
1994	34	77	(1,2)	111	257	368
1995	33	44	(1,2)	77	257	334
1996	30	60	(1,2)	90	251	341
1997	27	52	(1,2)	79	267	346
1998	29	44	(1,2,3)	73	266	339
1999	30	49	(1,2)	79	250	329
2000	32	57	(1,2)	89	238	327
2001	34	60	(1,2)	94	220	314
2002	32	47	(1,2)	79	215	294
2003	19	47	(1,2)	66	208	274
2004	31	54	(1,2)	85	201	286
2005	8	41	(1,2,4)	49	197	246
2006	1 **	6 **	(1,2,4)	7 **	0	7
2007	0	0		0	0	0
2008	0	0		0	0	0
2009						
2010	2	30	(2)	32		

*** Spanish purse seiners are those with licences that landed anchovy**

(1) Only purse seiners having catch anchovy at least once a year but fishing sardine most of the time

(2) only trawlers that targeted anchovy (annual catch > 50 t)

(3) doubtful in terms of separation between gears because of misreporting

(4) Provisional estimate

**** French number of boats involved in the experimental fishery; not the actual size of the fleet**

Table A.2.2. Approximate figures for the anchovy fleet and fishing effort displacement for the the period 2005-2009 (based on reports from stakeholders 28th August 2009, provided by the SWW RAC). Report vers = report to add; bolincheurs sud bretagne = purse seiners in southern Brittany; chinchard = horse mackerel; maquerau = mackerel; thon rouge = bluefin tuna; thon blanc = albacore; Autres = others

Fishing ports	Seiners		Pelagic trawlers		report vers												number of targeted species
					sardine		chinchard		maquereau		thon rouge		thon blanc		autres		
	2005	2009	2005	2009													
Galice	67	61			1	15,3	1	15,3	1	15,3					1	15,3	4
Asturies	10	6			1	3,0	1	3,0									2
Cantabrie	54	47			1	9,4	1	9,4	1	9,4	1	9,4	1	9,4			5
Vizcaya	25	25			1	5,0	1	5,0	1	5,0	1	5	1	5			5
Guipuzkoa	52	44			1	8,8	1	8,8			1	8,8	1	8,8	1	8,8	5
StJean de Luz	8	8	4	4			1	12,0									1
la Turballe			39	23									1	11,5	1	11,5	2
St Gilles			24	14	1	0,0					1	0					2
Bolincheurs sud bretagne	8	8			1	2,7	1	2,7							1	2,7	3

2010 St jena de luz 2 Lorient 2 La Turbballe 20 St Gilles 6 (15 pairs of pair pelagic trawlers)

A.3. Ecosystem aspects

Anchovy is a prey species for other pelagic and demersal species in the Bay of Biscay, and also for cetaceans and birds.

The recruitment depends strongly on environmental factors. Two environmental recruitment indices have been considered during the last 10 years: i) Borja's *et al.* (1998) index, which is an upwelling index, and ii) Allain's *et al.* (2001) index, which is a combination of upwelling and stratification breakdown. Allain's model was reviewed by Huret & Petitgas (WD 2007 in ICES2008) including a) the previous "upwelling" index, plus a new "stratification" index according to a new hydrodynamic model and b) an adult spatial indicator. The role of the Eastern Atlantic pattern in relation to the Upwelling index and the recruitment of anchovy have also been recently pointed out (Borja *et al.*, 2008). Other approaches based on coupling spawning habitat with hydrodynamic and production models are being tried for this anchovy population with promising results (Allain *et al.*, 2007).

The significance and reliability of all these indices is considered still insufficient for their consideration in the provision of management advice and no update was provided on their performance for the meeting in 2010 of WGANSA. Recent reviews have suggested that comparison with global indexes and correlation analysis may not be the best approach to understand and consequently predict recruitment in small pelagic fish (Barange *et al.*, 2009).

Fernandes et al (2010) presents an alternative to attempt to relate environmental indices with recruitment by means of linear models. It uses machine-learning techniques to obtain the probability of having a recruitment discretized into low, medium and high classes depending on environmental variables. The proposed methodology consists of performing supervised predictors discretization, carrying out supervised predictors selection and learning a 'naive Bayes' classifier. The approach can be applied to a dataset where the values of the recruitment have been discretized by the end-user, or the recruitment discretization can be part of the proposed model-building process in a bootstrap scheme. The results up to now are promising.

B. Data

B.1. Commercial catches:

Fishery closed from July 2006 to December 2009. reopened with 7,000t the 1st of March 2010

Annual Landings are available since 1940. The fishing statistics are considered accurate. Discards are not measured and hence not included in the assessment, but nowadays they are considered not relevant for the two fleets. In the past (late eighties and early nineties for the French Pelagic trawlers and sixties and seventies for the Spanish Purse seine fleet) they seemed to be more relevant (according to disputes among fishermen), but were never quantified.

B.2. Biological

- Catches at length and catches at age are known since 1984 for Spain and since 1987 for France. They are obtained by applying to the monthly Length distributions half year or quarterly ALKs (and when possible monthly ALKs, as for the Spanish fishery in spring). Biological sampling of the catches has been generally sufficient, except for 2000 and 2001, when an increase of the sampling effort seemed useful to have a better knowledge of the age structure of the catches during the second semester in the North of the Bay of Biscay. Complete age composition and mean weight at age on half year basis, were reported in ICES (2008- WGANC report).
- Age reading is considered accurate. The most recent cross reading exchanges and workshop between Spain and France took place in 2005 and 2006 respectively (Uriarte *et al.,* 2006 and 2007). The overall level of agreement and precision in anchovy age reading determinations seems to be satisfactory: Most of the anchovy otoliths were well classified by most of the readers during the 2006 workshop (with an average agreement of 92.7 % and a CV of 9.2%). CVs were on average smaller than 15% for any age, although individual CVs for ages or readers might be 30-35%. A new otolith exchange and age reading workshop took place in November 2009.
- Anchovies are mature at their 1st year of life.
- Growth in weight and length are well known from Surveys and from the monitoring of the fishery (Uriarte *et al.*, 1996).
- Natural mortality is fixed at 1.2 as an average of varying values obtained under the assumption of past DEPM providing absolute estimates of the population in numbers at age (*Uriarte et al.*, 1996). This parameter is considered to vary between years, but it is assumed to be constant for the assessment of the stock.
- In the Bayesian Biomass Model, the parameter *g* describes the annual change in mass of the population by encapsulating the growth in weight (G) and the natural Mortality (M) of the population as G-M (0.52-1.2=-0.68)

B.3. Surveys

Spring surveys: series of DEPM(Daily egg production method) and acoustic surveys in Spring every year.

The population is monitored by the two annual surveys carried out in spring on the spawning stock, namely, the Daily Egg Production Method (since 1987 with a gap in 1993) (Santiago and Sanz, 1992; Motos *et al.*, 2005) and the Acoustics surveys (regularly since 1989, although surveys were also conducted in 1983, 1984 and some in the seventies) (Massé 1988, 1994, 1996). Both surveys provide spawning biomass and population at age estimates. The surveys have shown pronounced inter-annual variability of biomass according to the pulse of recruitments, since one year old anchovies can conform up to more than 75% of the spawning population. Spawning area and biomass are positive and closely related, revealing expansion of the area occupied by the population when SSB increases (Uriarte *et al.*, 1996, Somarakis *et al.*, 2004).

This survey based monitoring system provides population estimates by the middle of the year, when about half of the annual catches have been already taken; and provide very little information about the anchovy population in the next year, since the bulk of it will consist of 1 year old anchovies being born at the time the surveys take place. Spawning Biomass in spring equals total stock biomass since all anchovies are mature (the youngest being 1 year old by then).

B.3.1 Anchovy Daily Egg Production Method

B.3.1.1 The DEPM model

The anchovy spawning stock biomass estimates is derived according to Parker (1980) and Stauffer & Picquelle (1980) from the ratio between daily production of eggs in the sea and the daily specific fecundity of the adult population:

Equation 1 $$SSB = P_{tot}/DF = \frac{P_0 \cdot A+}{k \cdot R \cdot F \cdot S/W}$$

Where,

SSB = Spawning stock biomass in metric tons

P_{tot} = Total daily egg production in the sampled area

P_0 = daily egg production per surface unit in the sampled area

A+ = Spawning area, in sampling units

DF = Daily specific fecundity. $DF = \frac{k \cdot R \cdot F \cdot S}{W}$

W = Average weight of mature females in grams,

R = Sex ratio, fraction of population that are mature females, by weight.

F = Batch fecundity, numbers of eggs spawned per mature females per batch

S = Fraction of mature females spawning per day

k = Conversion factor from gram to metric tons (10^6)

An estimate of an approximate variance and bias for the biomass estimator derived using the *delta* method (Seber, 1982, *in* Stauffer & Picquelle, *op. cit.*) was also developed by the latter authors.

Population estimates of numbers at age are derived as follows:

Equation 2 $$N_a = N \cdot E_a = \frac{SSB}{W_t} \cdot E_a$$

Where,

Na = Population estimate of numbers at age *a*.

N = Total spawning stock estimate in numbers. $N = \frac{SSB}{W_t}$

B = spawning stock biomass estimate.

Wt = average weight of anchovies in the population.

Ea = Relative frequency (in numbers) of age *a* in the population.

Variance estimate of the anchovy stock in numbers at age and total is derived applying the delta method.

B.3.1.2 Collection of plankton samples

Every year the area covered to collect the plankton samples is the southeast of the Bay of Biscay which corresponds to the main spawning area and season of anchovy.

Predetermined distributions of the vertical hauls that will be performed with the PairoVET net are shown in **Figure B.3.1.2.1**. The strategy of egg sampling is as follow: a systematic central sampling scheme with random origin and sampling intensity depending on the egg abundance found. Stations are located every 3 miles, along 15-mile-apart transects perpendicular to the coast. The sampling strategy is adaptive. When the egg abundances found are relatively high, additional transects separated by 7.5 nm are completed.

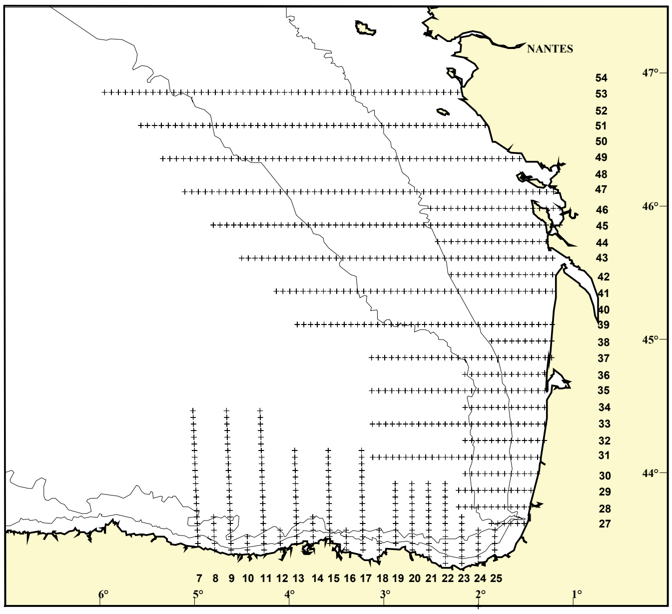


Figure B.3.1.2.1: Predetermined stations of the vertical hauls (PairoVET) that could be performed during the survey

The Continuous Underway Fish Egg Sampler (CUFES) is also used to record the eggs found at 3m depth. The samples obtained are immediately checked under the microscope so that presence/absence of anchovy eggs is detected in real time. This allowed knowing whether there were anchovy eggs in the area. When anchovy eggs are not found in 6 consecutive CUFES samples in the oceanic area, transect is left.

A vertical plankton haul is performed in each sampling station, using a PairoVET net (2-Calvet nets, Smith *et al.*, 1985 in Lasker, 1985) with a mouth aperture of 0.05 m^2 each CalVET. The frame was equipped with nets of 150 µm. The net is lowered to a maximum depth of 100 m or 5 m above the bottom in shallower waters. After allowing 10 seconds at the maximum depth for stabilisation, the net is retrieved to the surface at a speed of 1 m s^{-1}. A 45 kg depressor was used to allow for correctly deploying the net. "G.O. 2030" flowmeters were used to know the amount of water filtered during the tow.

Immediately after the haul, the net is washed and the samples obtained are fixed in formaldehyde 4% buffered with sodium tetra borate in sea water. After 6h of fixing, anchovy, sardine and other species eggs are identified and sorted out on board. Afterwards, in the laboratory a percentage of the samples are checked to assess the quality of the sorting made at sea. According to that a portion of the samples are sorted again to assure no eggs are left. In the laboratory the anchovy eggs are staged (Moser and Alshtrom, 1985).

During the survey, the presence/absence of eggs was recorded per PairoVET station and the area where anchovy eggs occurred was quantified. The spawning area was delimited with the outer zero anchovy egg stations. It contains some inner zero egg stations embedded on it (Picquelle and Stauffer, 1985). Following the systematic central sampling scheme (Cochran, 1977) each station was located in the centre of a rectangle. Egg Abundance found at a particular station was assumed to represent the abundance in the whole rectangle. The area represented by each station was measured. A standard station has a surface of 45 squared nautical miles (154 km^2) = 3 (distance between two consecutive stations) x 15 (distance between tow consecutive transects) nautical miles. Since sampling was adaptive, station area changed according to sampling intensity.

Real depth, temperature, salinity and chlorophyll profiles are obtained in every station using a CTD RBR-XR420 coupled to the PairoVET. In addition, surface temperature and salinity is recorded in each station with a manual termosalinometer WTW LF197.Moreover current data are obtained all along the survey with an ADCP(Acoustic Doppler Current Profiles).In some point determinate previously to the survey, water is filtered from the surface to obtain chlorophyll samples.

B.3.1.3 Collection of adult samples

In 1987 and 1988 the samples were obtained from commercial purse seines, the adult sampling was opportunistic. From years 1989 to 2005 the adult samples were obtained both from commercial purse seines and a research vessel with pelagic trawl so the adult sampling was both opportunistic and directed. Since 2006 the samples are obtained from a research vessel with pelagic trawl but not from the purse seines due to the closure of the fishery so the adult sampling is only directed not opportunistic. Since the reopening of the fisheries in March 2010 the commercial purse seines are providing again samples for the analysis apart from the ones from the research vessels.

The research vessel pelagic trawler covers the same area as the plankton vessel. When the plankton vessel encountered areas with anchovy eggs, the pelagic trawler is directed to those areas to fish. In each haul 100 individuals of each species are measure. Immediately after fishing, anchovy is sorted from the bulk of the catch and a sample of near 2 Kg is selected at random. Sampling finished as soon as a minimum of 1 kg or 60 anchovies are sexed, and from those, 25 non-hydrated females (NHF) are preserved. Sampling is also stopped when more than 120 anchovies have to be sexed to achieve the target of 25 NHF. Moreover, otoliths are extracted to obtain the age composition per sample.

In the case the sample are obtained from the purse seines a sample of near 2kg is selected from the fishing and are directly kept in 4% formaldehyde. Afterwards, in the laboratory the samples are process in the same way as explained above.

B.3.1.4 Total daily egg production estimates

When all the anchovy eggs are sorted and staged, it is possible to estimate total daily egg production (P_{tot}). This is calculated as the product between the daily egg production (P_0) and the spawning area (SA)

$$P_{tot} = P_0\ SA$$

A standard sampling station represents a surface of 45 nm^2 (i.e. 154 km^2). Since the sampling was adaptive, area per station changes according to the sampling intensity and the cut of the coast. The total area is calculated as the sum of the area represented by each station. The spawning area (SA) is delimited with the outer zero anchovy egg stations but it can contain some inner zero stations embedded. The spawning area is computed as the sum of the area represented by the stations within the spawning area.

The staged eggs are transformed into daily cohort abundances using the Bayesian ageing method (ICES 2004) Daily egg production (P_0) and daily mortality rates (Z) are estimated by fitting an exponential mortality model to the egg abundance by cohorts and corresponding mean age.

The model is fitted as a Generalised Linear Model (GLM) with Negative Binomial distribution and log link.

The ageing process and the model fitting are repeated until convergence. Eggs younger than 4 hours and older than 90% of the incubation time are removed from the model fitting to avoid any possible bias.

B3.1.5 Adult parameters and Daily Fecundity estimates

The DF estimate for this WGANSA in June is obtained from a linear regression model between DF and sea surface temperature (SST). Two weeks after arriving from the survey the adult parameters are not processed yet, uniquely the anchovies were weighted, measured, sexed and the otoliths were extracted, consequently Daly Fecundity has to be derived from the past historical series. Afterwards in the ICES WGACEGG in November the complete DEPM with all the adult parameters estimates is presented and approval. This occurred since 2005 when the advice started demanding SSB estimates in June, however the historical series of DF is being revised within WGACEGG (ICES 2009). Until DF is fully revised and its relationship with temperature corroborated by WGACEGG, the WGANSA decided to use the historical mean of DF (63.39 egg/ g per day) to obtain the preliminary SSB estimate for June.

From the whole set of adult samples gathered during the survey, a subset is chosen for final processing with the criterion of collection within ±5 days of the egg sampling in the same particular area. In the last years the samples are collected within the same day as the egg sampling. These samples are used to obtain adult parameters estimates leading to the estimate of Daily Fecundity, i.e. batch fecundity, spawning fraction, average female weight and sex ratio. These adult parameters are estimates for November as follows:

Sex Ratio (R): Given the large variability among samples of the sex ratio and taking into account that for most of the years when the DEPM has been applied to this population the final estimate has come out to be not significantly different from 50 % for each sex (in numbers), since 1994 the proportion of mature females per sample is being assumed to be equal to 1:1 in numbers. This leads to adopt as R the value of the average sample ratio between the average female weight and the sum of the average female and male weights of the anchovies in each of the samples.

Total weight of hydrated females is corrected for the increase of weight due to hydration. Data on gonad-free-weight (Wgf) and correspondent total weight (W) of non hydrated females is fitted by a linear regression model. Gonad-free-weight of hydrated anchovies is then transformed to total weight by applying the following equation:

$$W = -a + b * W_{gf}$$

For the **Batch fecundity (F)** estimates i.e. number of eggs laid per batch and female, the hydrated egg method was followed (Hunter et al, 1985). The number of hydrated oocytes in gonads of a set of hydrated females is counted. This number is deduced from a sub-sampling of the hydrated ovary: Three pieces of approximately 50 mg are removed from different parts of each ovary, weighted with precision of 0.1 mg and the number of hydrated oocytes counted. Sanz & Uriarte (1989) showed that 3 tissue samples per ovary are adequate to get good precision in the final batch fecundity estimate and the location of sub-samples within the ovary do not affect it. Finally the number of hydrated oocytes in the sub-sample is raised to the total gonad of the female according to the ratio between the weights of the gonad and the weight sub-sampled.

A linear regression between female weight and batch fecundity is established for the subset of hydrated females and used to calculate the batch fecundity of all mature females. The average of the batch fecundity estimates for the females of each sample as derived from the gonad free weight – eggs per batch relationship is then used as the sample estimate of batch fecundity.

Moreover, an analysis is conducted to verify if there are differences in the batch fecundity if strata are defined to estimate SSB.

To estimate **Spawning Frequency (S)**, i.e. the proportion of females spawning per day, until the new series of spawning frequency (S) is accepted a model based on the historical series was considered. This model relates S linearly with Sea Surface Temperature (SST).

Mean and variance of the adult parameters are estimated following equations for cluster sampling (as suggested by Picquelle & Stauffer, 1985):

Equation 3
$$Y = \frac{\sum_{i=1}^{n} M_i \, y_i}{\sum_{i=1}^{n} M_i}$$

Equation 4
$$Var(Y) = \frac{\sum_{i=1}^{n} M_i^{2} (y_i - Y)^2}{\overline{M}^2 \, n(n-1)}$$

Where,

Y_i is an estimate of whatever adult parameter from sample *i* and M_i is the size of the cluster corresponding to sample *i*. occasionally a station produced a very small catch, resulting in a small sub-sample size. To reflect the actual size of the station and its lower reliability, small samples were given less weight in the estimate. For the estimation of W, F and S, a weighting factor was used, which equalled to 1 when the number of mature females in station *i* (M_i) was 20 or greater and it equalled to $M_i/20$ otherwise. In the case of R when the total weight of the sample was less than 800 g then the weighting factor was equal to total weight of the sample divided by 800g, otherwise it was set equal to 1. In summary for the estimation of the parameters of the Daily Fecundity we are using a threshold-weighting factor (TWF) under the assumption of homogeneous fecundity parameters within each stratum.

B.3.1.6 SSB estimates

In the WGANSA during June the Spawning Stock Biomass is preliminary estimates as the ratio between the total egg production (P_{tot}) and Daily Fecundity (DF) estimates and its variance is computed using the Delta method (Seber, *1982*):

$$\hat{Var}[SSB] = \frac{\hat{Var}[Ptot]}{DF^2} + \frac{P_{tot}^{\ 2}\hat{Var}[DF]}{DF^4}$$

The definitive SSB estimate with all the adult parameters is presented and approval at the WGACEGG during November.

B.3.1.7 Numbers at age

For the purposes of producing population at age estimates, the age readings based on otoliths from the adult samples collected were available. Estimates of anchovy mean weights and proportions at age in the adult population were computed as a weighted average of the mean weight and age composition per samples where the weights were proportional to the population (in numbers) in each stratum. These weighting factors are proportional to the egg abundance per stratum divided by the numbers of samples in the stratum and the mean weight of anchovy per sample. Weighting factors were allocated according to the relative egg abundance and to the amount of samples in the strata defined for the proposed of the estimation of the numbers at age. These strata are defined each year depending on the distribution of the adult samples i.e. size, weight, age and the distribution of the anchovy eggs.

Mean and variance of the adult parameters of the Population in numbers at age and the Population length distribution (total weight, proportion by ages and length distribution) are estimated following equations 4 and 5 for cluster sampling.

B.3.2. Anchovy acoustic indices

Acoustic surveys are carried out every year in the Bay of Biscay in spring on board the French research vessel Thalassa. The objective of PELGAS surveys is to study the abundance and distribution of pelagic fish in the Bay of Biscay. The main target species is anchovy but it will be considered in a multi-specific context as species located in the centre of ecosystem.

These surveys are connected with IFREMER programs on data collection for monitoring and management of fisheries and ecosystemic approach for fisheries. This task is formally included in the first priorities defined by the Commission regulation EU N° 199/2008 of 06 November 2008 establishing the minimum and extended Community programmes for the collection of data in the fisheries sector and laying down detailed rules for the application of Council Regulation (EC) No 1543/2000. These surveys must be considered in the frame of the Ifremer fisheries ecology action "resources variability" which is the French contribution to the international Globec programme. It is planned with Spain and Portugal in order to have most of the potential area to be covered from Gibraltar to Brest with the same protocol for sampling strategy. Data are available for the ICES working groups WGANSA, WGWIDE and WGACEGG.

B.3.2.1. Method and sampling strategy

In the frame of an ecosystemic approach, the pelagic ecosystem is characterized at each trophic level. In this objective, to assess an optimum horizontal and vertical description of the area, two types of actions are combined:

- Continuous acquisition by storing acoustic data from five different frequencies and pumping sea-water under the surface in order to evaluate the number of fish eggs using a CUFES system (Continuous Under-water Fish Eggs Sampler), and
- Discrete sampling at stations (by trawls, plankton nets, CTD). Satellite imagery (temperature and sea colour) and modelisation will be also used before and during the cruise to recognise the main physical and biological structures and to improve the sampling strategy. Concurrently, a visual counting and identification of cetaceans (from board) and of birds (by plane) will be carried out in order to characterise the higher level predators of the pelagic ecosystem.

Satellite imagery (temperature and sea colour) and modelisation are also used before and during the cruise to recognise the main physical and biological structures and to improve the sampling strategy.

Concurrently, a visual counting and identification of cetaceans and of birds (from board) is carried out in order to characterise the top predators of the pelagic ecosystem.

The strategy was the identical to previous surveys (2000 to 2009):

- Acoustic data were collected along systematic parallel transects perpendicular to the French coast (figure 1.1.1). The length of the ESDU (Elementary Sampling Distance Unit) was 1 mile and the transects were uniformly spaced by 12 nautical miles covering the continental shelf from 20 m depth to the shelf break.

- Acoustic data were collected only during the day because of pelagic fish behaviour in this area. These species are usually dispersed very close to the surface during the night and so "disappear" in the blind layer for the echo sounder between the surface and 8 m depth.

Two echo-sounders are usually used during surveys (SIMRAD EK60 for vertical echo-sounding and OSSIAN 500 on the pelagic trawl). In 2009 the SIMRAD ME70 has been used for multi-beam visualisation. Energies and samples provided by split beam transducers (5 frequencies EK60, 18, 38, 70, 120 and 200 kHz), simple beam (OSSIAN 49 kHz) and multibeam echo-sounder were simultaneously visualised, stored using the MOVIES+ software and at the same standard HAC format.

The calibration method is the same that the one described for the previous years (see W.D. 2001) with a tungsten sphere hanged up 20 m below the transducer and is generally performed at anchorage in front of Machichaco cap or in the Douarnenez bay, in the west side of Brittany, in optimum meteorological conditions.

Acoustic data are collected by Thalassa along the totality of the daylight route from which about 2000 nautical miles on one way transect are usable for assessment. Fish are measured on board (for all species) and otoliths (for anchovy and sardine) are collected for age determinations.

B.3.2.2. Echoes scrutinizing

Most of the acoustic data along the transects are processed and scrutinised during the survey and are generally available one week after the end of the survey (figure 2.2.1). Acoustic energies (Sa) are cleaned by sorting only fish energies (excluding bottom echoes, parasites, plankton, etc.) and classified into several categories of echo-traces according to the year fish (species) structures.

Some categories are standard such as:

D1 – energies attributed to mackerel, horse mackerel, blue whiting, divers demersal fish, corresponding to cloudy schools or layers (sometimes small dispersed points) close to the bottom or of small drops in a 10m height layer close to the bottom.

D2 –energies attributed to anchovy, sprat, sardine corresponding to the usual echo-traces observed in this area since more than 15 years, constituted by schools well designed, mainly situated between the bottom and 50 meters above. These echoes are typical of clupeids in coastal areas and sometime more offshore.

D3 – energies attributed to blue whiting and myctophids offshore, just closed to the shelf-break.

D4 – energies attributed to sardine, mackerel or anchovy corresponding to small and dense echoes, very close to the surface.

D6 – energies attributed to a mix, usually between 50 and 100 m depth when D1 and D2 were not separable

Some particular categories are usually specifically designed according to several identifications during the survey (when Thalassa and/or commercial vessels hauls are available), such as:

D7 – energies attributed exclusively to sardine (big and very dense schools).

D5 – energies attributed to small horse mackerel only when they are gathered in very dense schools this category is usually used for typical echoes which occur along particular surveys. In the case of 2010, it was used to gather energies which occurred all along the transects in the. northern platform where a continuous cover of mainly blue whiting was observed.

B.3.2.3. Data processing

The global area is split into several strata where coherent communities are observed (species associations) in order to minimise the variability due to the variable mixing of species. For each stratum, a mean energy is calculated for each type of echoes and the area measured. A mean haul for the strata is calculated to get the proportion of species into the strata. This is obtained by estimating the average of species proportions weighted by the energy surrounding haul positions. Energies are therefore converted into biomass by applying catch ratio, length distributions and TS relationships. The calculation procedure for biomass estimate and variance is described in Petitgas et.al 2003.

The TS relationships used since 2000 are still the same and as following:

Sardine, anchovy & sprat : TS = 20 Log L – 71.2

Horse-mackerel : TS = 20 Log L – 68.7

Blue whiting : TS = 20 Log L – 67.0

Mackerel : TS = 20 Log L – 86.0

The mean abundance per species in a stratum (tons m.n.$^{-2}$) is calculated as:

$$M_e(k)=\sum_D \overline{s}_A(D,k)\overline{X}_e(D,k)$$

and total biomass (tons) by : $B_e=\sum_k A(k)Me(k)$

where,

k : strata index
D : echo type
e : species

S_A : Average S_A (NASC) in the strata (m2/n.mi.2)
X_e : species proportion coefficient (weighted by energy around each haul) (tons m^{-2})
A : area of the strata (m.n.^{2})
Then variance estimate is:

$$Var.M_e(k)=\sum_D \overline{s}_A^{\,2}(D,k)Var[X_e(D,k)]/n.cha(k)+\overline{X}_e^{\,2}\,\mathrm{var}[s_A(D,k)]/n.esu(D,k)$$

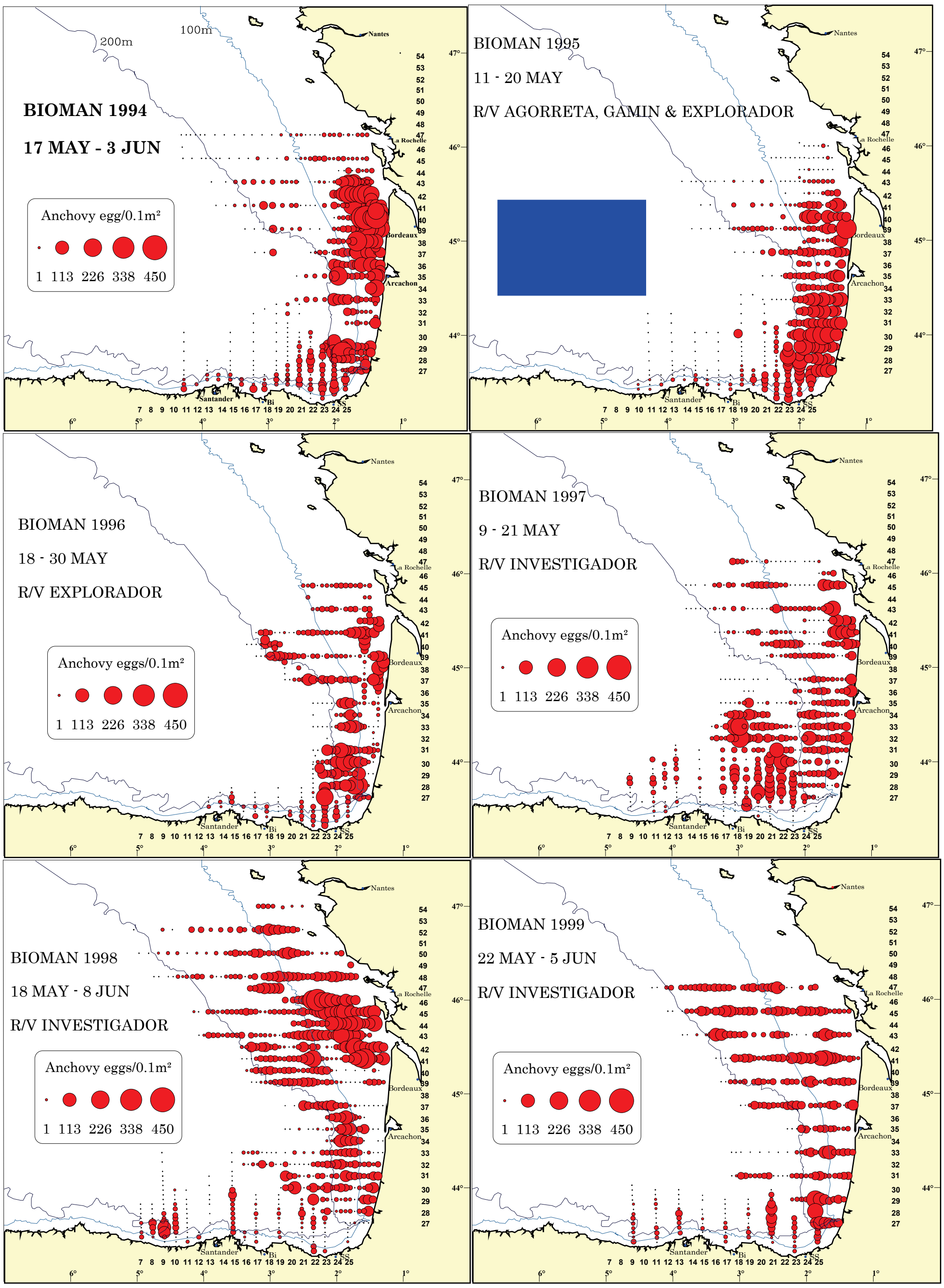
$$Var.B_e=\sum_k A^2(k)Var.Me(k)$$

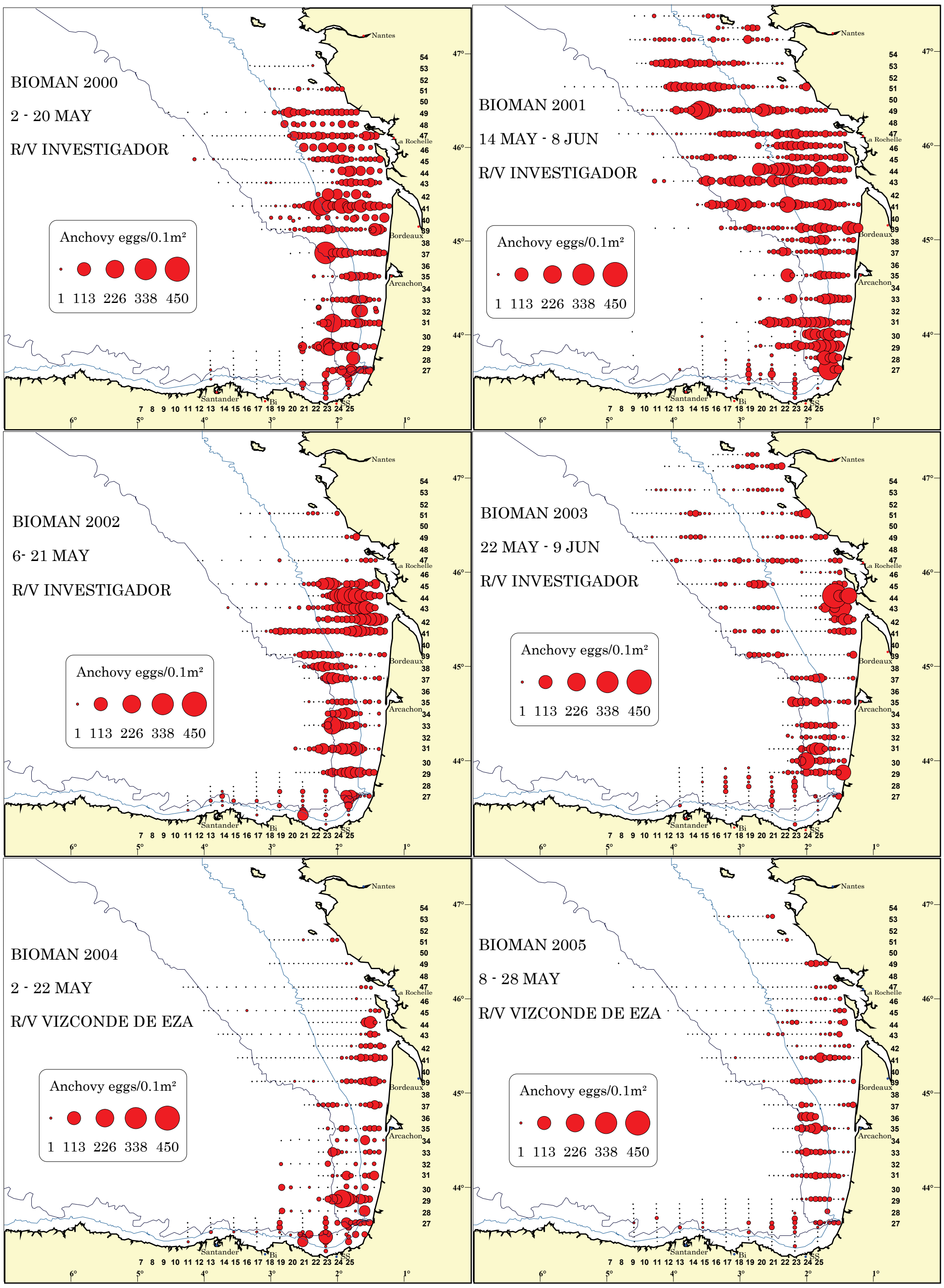
$$cv=\sqrt{Var.Be}/Be$$

At the end, density in numbers and biomass by length and age are calculated for each species in each ESDU according to the nearest haul length composition. These numbers and biomass are weighted by the biomass in each stratum and data are used for spatial distributions by length and age.

The detailed protocol for these surveys (strategy and processing) is described in annex 6 of WGACEGG report in 2009

B.3.3 Historical series DEPM and acoustic surveys




BIOMAN 2000
2 - 20 MAY
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2001
14 MAY - 8 JUN
R/V INVESTIGADOR
BIOMAN 2002
6- 21 MAY
R/V INVESTIGADOR
BIOMAN 2003
22 MAY - 9 JUN
R/V INVESTIGADOR
BIOMAN 2004
2 - 22 MAY
R/V VIZCONDE DE EZA
BIOMAN 2005
8 - 28 MAY
R/V VIZCONDE DE EZA
Nantes
La Rochelle
Bordeaux
Arcachon
Santander
Bi
SS

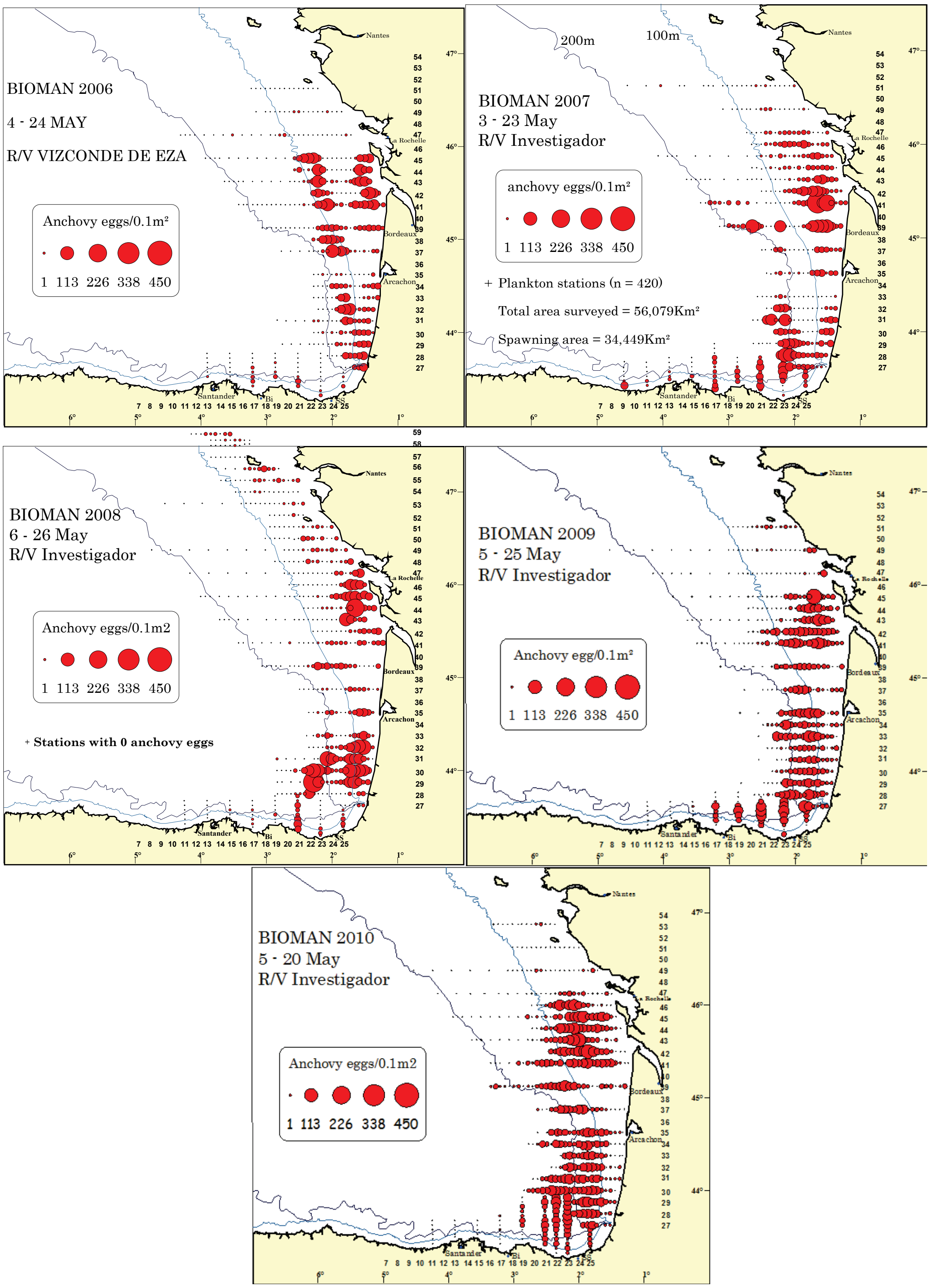
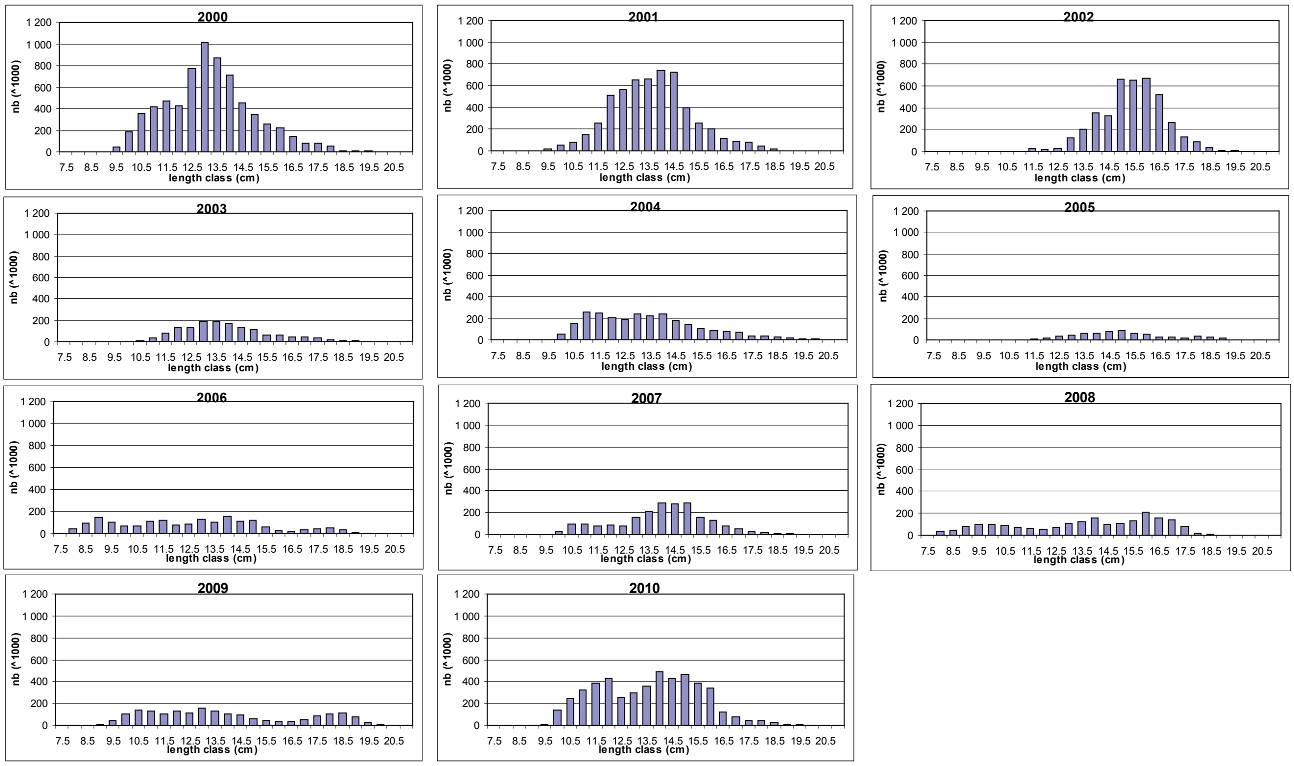
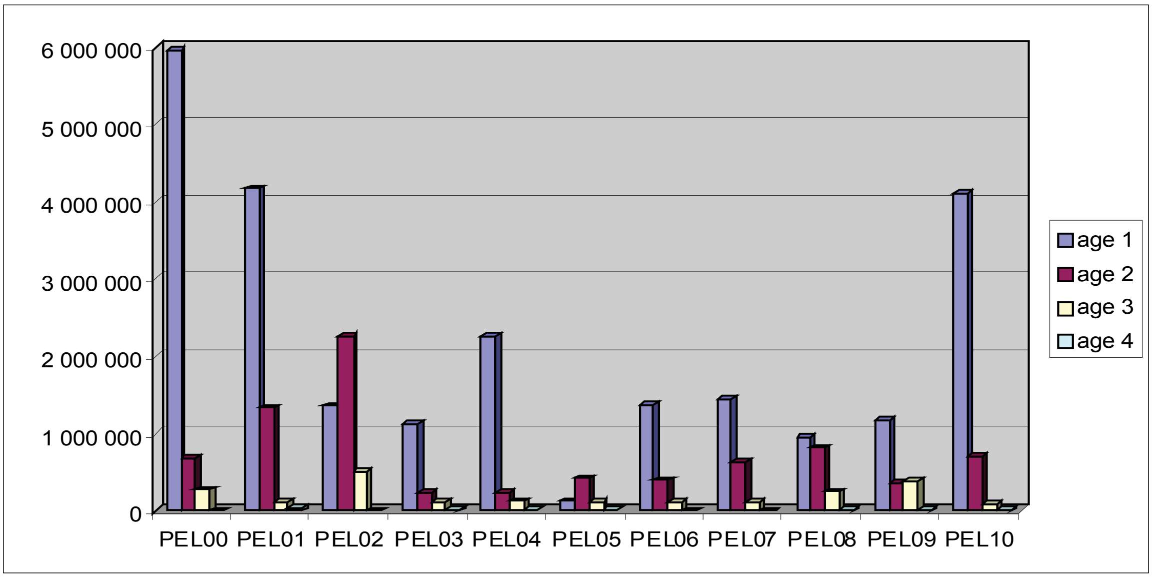
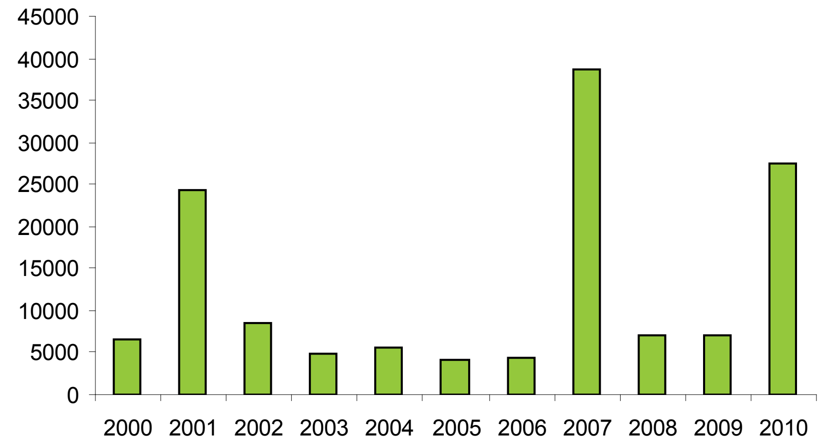


Figure B.3.3.1: Anchovy egg distribution from 1998 to 2009.The circles represent the anchovy egg abundance /0.1m² encountered in each plankton station.

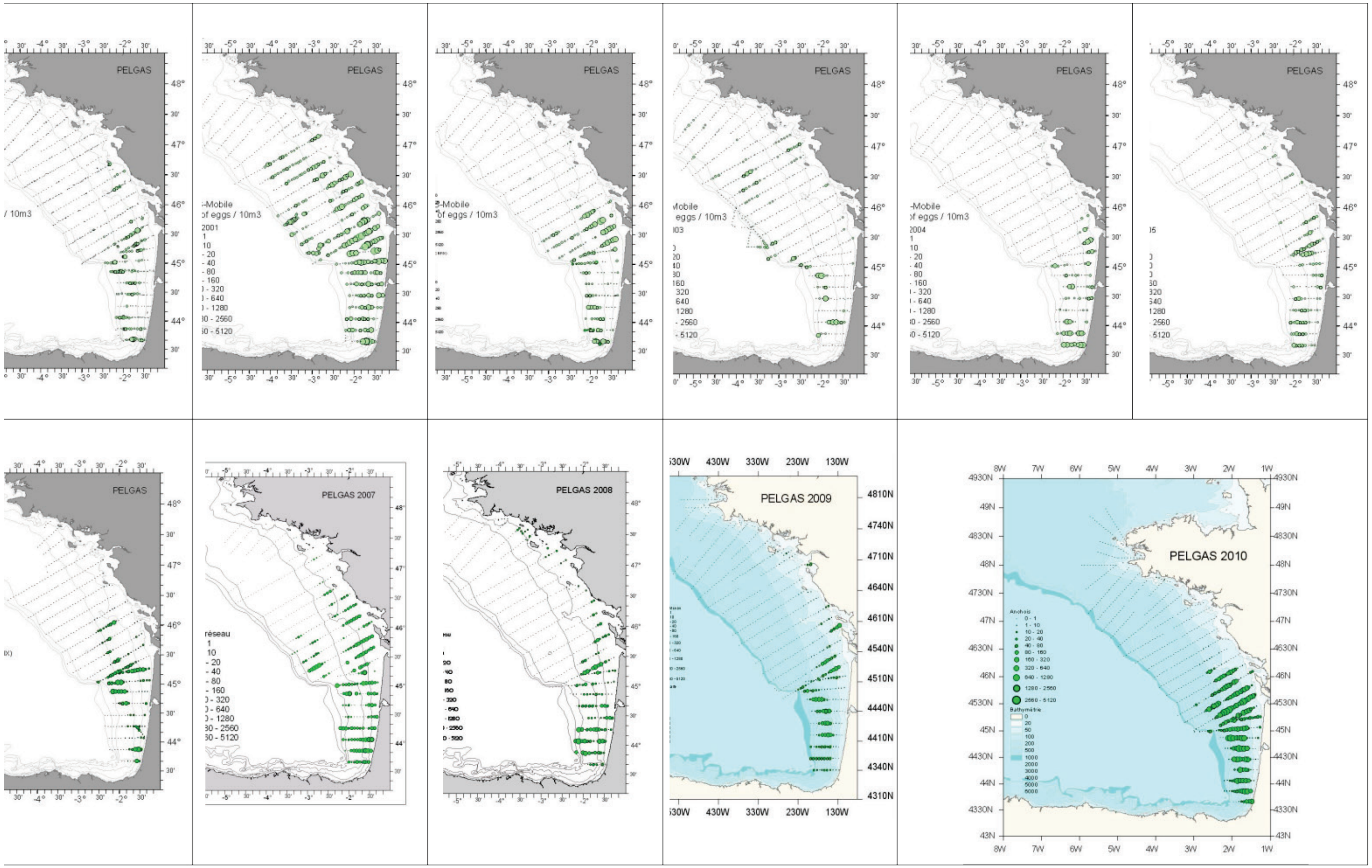


Length composition of adults of anchovy as estimated by acoustics since 2000 during PELGAS surveys.





Number of eggs observed during PELGAS surveys with CUFES from 2000 to 2010



Distribution of anchovy eggs observed with CUFES during PELGAS surveys from 2000 to 2010 (number for 10m³).

B.3.4 Autumn surveys on Juveniles, still under testing period

In recent years two series of acoustic surveys on juvenile anchovy (JUVENA and PELACUS10) have been launched in September-October, expecting that in the future the estimates can allow forecasting the strength of the anchovy recruitment which will enter the fishery the next year (ICES 2008 – WGACEGG report). Both surveys were coordinated with WGACEGG and are being merged nowadays. These surveys are expected to provide further insights on the recruitment process and additional knowledge on the biology and ecology of the juveniles Despite the encouraging results obtained with the series of 6 years of data available, the lack of sufficient contrast in the recent levels of recruitments prevents a proper evaluation of its performance as a predictor and the series are therefore not yet used for improving the management advice for the population (ICES 2008 - WGANC report).

B.3.4.1 Juvena survey

B.3.4.1.1 Data acquisition

JUVENA surveys take place annually since 2003, around September. In the period 2003 to 2005, the area was covered onboard commercial purse seiners. Since 2006 in addition to purse seiners, an oceanographic vessel, the R/V Emma Bardán, was incorporated to the survey. The abundance estimation is obtained by means of acoustic methodology (MacLennan and Simmonds, 1992). The acoustic equipment includes split beam echo sounders Simrad EK60 (Kongsberg Simrad AS, Kongsberg, Norway). The transducers of 38 kHz and 120 kHz (and 200kHz since 2006) were installed looking vertically downwards, about 2.5 m deep, at the end of a tube attached to the side of the purse seiners and at the hull in the case of the R/V Emma Bardan. The transducers were calibrated using standard procedures (Foote *et al.* 1987). Fishing was based on purse seining up to 2005 but since then onwards both pelagic trawling and purse seines are being used for species identification and biological sampling, along with hydrological recordings. In addition, the spatial distribution of the juvenile population is studied along with their growth condition. Two boats have been used since 2005 and therefore some extension of the northern limits of the surveys thus facilitated.

The water column was sampled to depths of 200 m. A threshold of -100 dB was applied for data collection. Acoustic back-scattered energy by surface unit (S_A, MacLennan *et al.* 2002) was recorded for each geo-referenced ESDU (Echointegration Sampling Distance Unit) of 0.1 nautical mile (185.2 m). Fish identity and population size structure was obtained from fishing hauls and echotrace characteristics. The commercial vessels used a purse seine of about 400 m of perimeter and 75 m height to fish the samples to depths of 50 m and the R/V Emma Bardan used a pelagic trawl. Acoustic data, thresholded to -60 dB, was processed using Movies+ software (Ifremer) for biomass estimation and the processed data was represented in maps using Surfer (Golden Software Inc., CO, USA) and ArcView GIS. Hydrographic recording was made with CTD casts.

B.3.4.1.2 Sampling strategy

The sampling area covered the waters of the Bay of Biscay (being 5º W and 47º45′ N the limits). Sampling was started from the Southern part of the sampling area, the Cantabrian Sea, moving gradually to the North to cover the waters in front of the French Coast. The acoustic sampling was performed during the daytime, when the juveniles are supposed to aggregate in schools (Uriarte 2002 FAIR CT 97-3374) and can be distinguished from plankton structures.

The vessels followed parallel transects, spaced 15 nm., perpendicular to the coast along the sampling area, taking into account the expected spatial distribution of anchovy juveniles for these dates, that is, crossing the continental shelf in their way to the coast from offshore waters (Uriarte et al. 2001).

B.3.4.1.3 Other sources of information

During the summer, information from the commercial live bait tuna fishery was collected, in order to have knowledge about the spatial distribution and relative abundance of anchovy previous to the beginning of the survey. We continued collecting this information about the captures of the fleet during the survey itself. In addition we maintained a constant communication with the responsible of the survey Pelacus-10, conducted by the IEO and Ifremer, survey performed onboard R/V Thalassa with a double objective: juvenile abundance estimation and ecologic studies.

B.3.4.1.4 Biological processing

Each fishing haul was classified to species and a random sample of each species was measured to produce size frequencies of the communities under study. A complete biological sampling of the anchovy juveniles collected is performed in order to analyze biological parameters of the anchovy juvenile population, as the age, size or size-weight ratio. Using these and other environmental parameters we will try to obtain, in a long term, indexes of the state of condition of the juvenile population, in order to be able to improve the prediction of the strength of the recruitment.

B.3.4.1.5 Acoustic data processing

Acoustic data processing was performed by layer echo-integration by 0.1 nautical mile (s_A) of the first 65 m of the water column with Movies+ software, after noise filtering and bottom correction, increasing or decreasing this range when the vertical distribution of juveniles made it necessary.

The hauls were grouped by strata of homogeneous species and size composition. Inside each of these homogeneous strata, the echo-integrated acoustic energy s_A was assigned to species according to the composition of the hauls. Afterwards, the energy corresponding to each specie-size was converted to biomass using their corresponding conversion factor.

Each fish species has a different acoustic response, defined by its scattering cross section that measures the amount of the acoustic energy incident to the target that is scattered backwards. This scattering cross section depends upon specie *i* and the size of the target *j*, according to:

$$\sigma_{ij} = 10^{TS_j/10} = 10^{\{(a_i + b_i \log L_j)/10\}}$$

Here, L_j represents the size class, and the constants a_i and b_i are determined empirically for each species. For anchovy, we have used the following TS to length relationship:

$$TS_j = -72.6 + 20 \log L_j$$

The composition by size and species of each homogeneous stratum is obtained by averaging the composition of the individual hauls contained in the stratum, being the contribution of each haul weighted to the acoustic energy found in its vicinity (2 nm of diameter). Thus, given a homogeneous stratum with M hauls, if E_k is the mean acoustic energy in the vicinity of the haul k, w_i, the proportion of species i in the total capture of the stratum, is calculated as follows:

$$w_i = \sum_j w_{ij} = \sum_j \left(\frac{\sum_{k=1}^{M} \left(q_{ijk} \cdot E_k \big/ Q_k \right)}{\sum_{k=1}^{M} E_k} \right).$$

Being q_{ijk} the quantity (in mass) of species i and length j in the haul k; and Q_k, the total quantity of any species and size in the haul k.

In order to distinguish their own contribution, anchovy juveniles and adults were separated and treated as different species. Thus, the proportion of anchovy in the hauls of each stratum (w_{ij}) was multiplied by a age-length key to separate the proportion of adults and juveniles. Then, separated w_i were obtained for each.

Inside each homogeneous stratum, we calculated a mean scattering cross section for each species, by means of the size distribution of such specie obtained in the hauls of the stratum:

$$\langle \sigma_i \rangle = \frac{\sum_j w_{ij} \sigma_{ij}}{w_i}.$$

Let s_A be the calibration-corrected, echo-integrated energy by ESDU (0.1 nautical mile). The mean energy in each homogeneous stratum, $E_m = < s_A >$, is divided in terms of the size-species composition of the haul of the stratum. Thus, the energy for each species, E_i, is calculated as:

$$E_i = \frac{w_i \langle \sigma_i \rangle E_m}{\left(\sum_i w_i \langle \sigma_i \rangle \right)}$$

Here, the term inside the parenthesis sums over all the species in the stratum. Finally, the number of individuals F_i of each species is calculated as:

$$F_i = H \cdot l \frac{E_i}{\langle \sigma_i \rangle}$$

Where l is the length of the transect or semi-transect under the influence of the stratum and H is the distance between transect (about 15 nm.). To convert the number of juveniles to biomass, the size-length ratio obtained in each stratum is applied to obtain the average weight of the juveniles in the stratum:

$$< W_i > = a \cdot < L_i >^b$$

Thus, the biomass is obtained by multiplying F_i times $< W_i >$.

B.3.4.1.6 Commercial CPUE

According to literature, CPUE indices have been considered, as not reliable indicators of abundance for small pelagic fishes (Ulltang, 1982, Csirke 1988, Pitcher 1995, Mackinson *et al.* 1997). Current series of CPUE available for the Spanish Purse seine are not considered of utility for the monitoring of the fishery (Uriarte *et al.*, 2008).

C. Stock assessment method

Model used:

The assessment for the Bay of Biscay anchovy population is a Bayesian two-stage biomass-based model (BBM) (Ibaibarriaga *et al.*, 2008), where the population dynamics are described in terms of biomass with two distinct age groups, recruits or fish aged 1 year, and fish that are 2 or more years old. The biomass decreases exponentially on time by a factor g accounting for intrinsic rates of growth (G) and natural mortality (M) which are assumed year- and age-invariant.

Two periods are distinguished within each year. The first begins on 1 January, when it is assumed that age incrementing occurs and age 1 recruit enter the exploitable population, and runs to the date when the monitoring research surveys (acoustics and DEPM) take place. The second period covers the rest of the year (from 15th May to 31st December). Catch is assumed to be taken instantaneously within each of these periods.

The observation equations consist on log-normally distributed spawning stock biomass from the acoustics and DEPM surveys, where the biomass observed is proportional to the true population biomass by the catchability coefficient of each of the surveys, and the beta distributed age 1 biomass proportion from the acoustics and DEPM surveys, with mean given by the true age 1 biomass proportion in the population.

The model unknowns are the initial population biomass (in 1987), the recruitment each year, the catchability of the surveys and the variance related parameters of the observation equations. The model can be cast into a Bayesian state-space model framework where inference on the unknowns is done using Markov Chain Monte Carlo (MCMC).

Software used:

The model is implemented in BUGS (www.mrc-bsu.cam.ac.uk/bugs/) and it is run from R (www.r-project.org) using the package R2WinBUGS.

Model Options chosen:

Catchability for the DEPM SSB is set to 1 because it is assumed to be an absolute indicator of Biomass and for consistency with the past practice in the assessment of this stock. Catchability of the acoustic SSB is estimated. DEPM and acoustic surveys are assumed to provide unbiased proportion of age 1 biomass estimates in the stock. The first set of priors as defined in Ibaibarriaga et al. 2008 is used. The length of the MCMC run, the burn-in period (removal of the first draws to avoid dependency on the initial values) and the thinning to diminish autocorrelation should be enough to ensure convergence and obtain a representative joint posterior distribution of the parameters.

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year. Yes/No
Caton	Catch in tonnes by periods	1987-2010	1 to 2+	Yes
Canum	Catch at age in numbers by periods	1987-2010	1 & 2+	Yes
Weca	Weight at age in the commercial catch by periods	1987-2010	1 to 2+	Yes
Mprop	Proportion of natural mortality before spawning	Not applicable		
Fprop	Proportion of fishing mortality before spawning	Not applicable		
Matprop	Proportion mature at age	Not applicable		
Natmor	Natural mortality M=1.2	1987-2010	1 to 2+	No
G	Intrinsic growth rate G= 0.52	1987-2010	1 to 2+	No

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	DEPM SSB spring series	1987-2010 (with gap in 1993)	
Tuning fleet 2	Acoustic SSB spring series	1989-2010 (with gaps)	
Tuning fleet 3	DEPM P1 (B1/SSB) spring series	1987-2010 (with gaps)	
Tuning fleet 4	Acoustic P1 (B1/SSB) spring series	1989-2010 (with gaps)	

Prior distributions of the parameters:

The current prior distributions (see table below) are described and justified in Ibaibarriaga *et al.* (2008) and ICES WGANC (2008)

Parameter	Prior 1	
	Hyper-parameters	Median (95% CI)
q_{surv}	$\mu_{q_{surv}} = 0$	1 (0.1, 16.0)
	$\psi_{q_{surv}} = 0.5$	
ψ_{surv}	$a_{\psi_{surv}} = 0.8$	10 (0.2, 65.1)
	$b_{\psi_{surv}} = 0.05$	
ξ_{surv}	$\mu_{\xi_{surv}} = 5$	5 (0.6, 9.4)
	$\psi_{\xi_{surv}} = 0.2$	
B_0	$\mu_{B_0} = 10.5$	36 316 (5 116, 257 806)
	$\psi_{B_0} = 1.0$	
μ_R	$\mu_{\mu_R} = 9.8$	9.8 (7.0, 12.6)
	$\psi_{\mu_R} = 0.5$	
ψ_R	$a_{\psi_R} = 4$	1.8 (0.5, 4. 4)
	$b_{\psi_R} = 2$	
g	$\mu_g = \log(0.7)$	0.7 (0.1, 5.0)
	$\psi_g = 1$	

The benchmark workshop recommended to conduct some sensitivity analysis on the prior distributions. In particular, to test the effect of having more informative priors on the surveys' catchability and precision and on the g parameter. If this is done, any changes in the prior distributions of the parameters should be documented and justified in the ICES anchovy assessment working group report (WGANSA).

D. Short-Term Projection

<u>Model used:</u>

The Bayesian two-stage biomass-based model (Ibaibarriaga *et al.* 2008) used for the assessment of the stock is used to project the population one year forward from the current state and to analyse the probability of the population in the next year of being below the biological reference point Blim (21 000 tonnes) under a recruitment scenario based on the past recruitment series and under alternative catch options for the second half of the current year and the first half of next year.

The predictive distribution of recruitment at age 1 (in mass) in January next year is defined as a mixture of the past series of posterior distributions of recruitments as follows:

$$R_{2008} = \sum_{y=1987}^{2007} w_y \; p(R_y|\cdot\,),$$

where $p(R_y\,|\cdot)$ denotes the posterior distribution of recruitment in year y and w_y are the weights of the mixture distribution, such that $\sum w_y = 1$. These weights can be based on information about incoming recruitment or on assumptions regarding different scenarios.

Software used:

The projections are implemented in R (www.r-project.org)

Projection period:

One year ahead from the spawning period (15th May) in the last assessment year

Initial stock size:

Posterior distribution of SSB in the last assessment year

Maturity: NA

F and M before spawning: NA

Weight at age in the stock: NA

Weight at age in the catch: NA

Intrinsic growth rate (G):

Assumed constant same as in the assessment (G=0.52)

Natural mortality rate (M):

Assumed constant same as in the assessment (M=1.2)

Exploitation pattern:

Alternative options for splitting catches by periods are tested

Intermediate year assumptions: NA

Stock recruitment model used:

No implicit S/R model is used. Recruitment is sampled from the posterior distributions of past series recruitments. Different recruitment scenarios are constructed by giving different weights to the past series recruitments.

Procedures used for splitting projected catches: NA

E. Medium-Term Projections

No Medium term projections are applied to this fishery for the provision of advice by ICES. Long term projections (10 years ahead) were run by STECF in 2008 to set the basis of a management plan on anchovy to the EC, based on a Ricker stock recruitment relationship.

F. Long-Term Projections

No Long term projections are applied to this fishery for the provision of advice by ICES. Long term projections (10 years ahead) were run by STECF in 2008 to set the basis of a management plan on anchovy to the EC, based on a Ricker stock recruitment relationship.

G. Biological Reference Points

A stock/recruitment relationship is not explicitly used.

Current biological reference points for the Bay of Biscay anchovy were defined by ICES ACFM in October 2003 as follows:

	ICES considers that:	ICES proposes that:
Limits reference points	**B_{lim}** is 21,000 t, the lowest observed biomass in 2003 assessment.	B_{pa}= 33,000 t.
	There is no biological basis for defining F_{lim}.	F_{pa} be established between 1.0-1.2.
Target reference points		

Technical basis:

$B_{lim} = B_{loss} = 21{,}000$ t.	$B_{pa} = B_{loss} * 1.645$.
	F_{pa}= F for 50% spawning potential ratio, i.e., the F at which the SSB/R is half of what it would have been in the absence of fishing

H. Other Issues

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5.2 Stock Annex Anchovy in Division IXa

Quality Handbook ANNEX: A.5.2

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Anchovy in Division IXa
Working Group:	WGANSA (Working Group on the Assessment of Anchovy and Sardine)
Date:	24th June 2011
Revised by	Fernando Ramos

A. General

A.1. Stock definition

The distribution of anchovy in the Division IXa is nowadays mainly concentrated in the Spanish waters of the Gulf of Cádiz (Sub-division IXa-South, **Figure A.1.1**). Outside the main nucleus of the Gulf of Cádiz, resilient anchovy populations have been detected in all fishery independent surveys (ICES, 2007 b) and previous records on large catches in ICES areas IXa North, Central North and South (Algarve) suggest that abundance in those areas have been high in early years of the time series. In the south, outside the Gulf of Cádiz anchovy is abundant to the East of the Strait of Gibraltar, in the Mediterranean Sea (GFCM, 2002) as well as in northern Africa, where a combined Spanish-Morocco fishery produces landings of up to 12000 tn (Millán, 1992; García-Isarch *et al*., 2008).

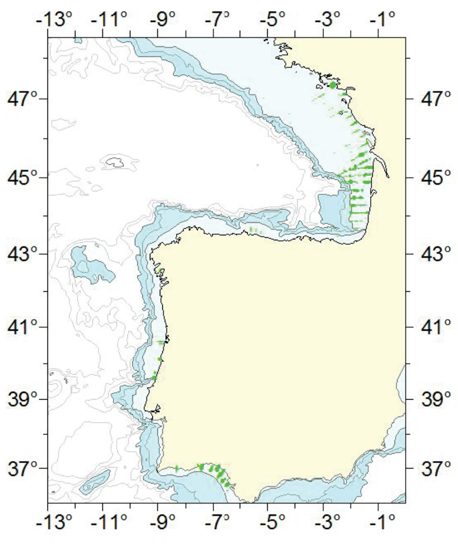

Figure A.1.1. Distribution of acoustic energy allocated to anchovy from the combined 2007 acoustic surveys off Iberia and the Armorican shelf (from ICES, 2009b).

A.2. Fishery

Anchovy harvesting along the Division IXa is at present carried out by the following fleets:

- o Portuguese purse-seine fleet
- o Portuguese trawl fleet
- o Portuguese artisanal fleet (although fishing with artisanal purse-seines)
- o Spanish purse-seine fleet
- o Spanish trawl fleet (in Subarea IXa-South (Cádiz))

Purse-seine fleets are the main responsibles for the anchovy fishery in the Division (usually more than 90% of total annual landings in the Division). Spanish fleets operate in Sub-divisions IXa-North (Southern Galicia) and IXa-South (Gulf of Cadiz), and the Portuguese ones along its national peninsular fishing grounds (Sub-divisions IXa-Central North, -Central South and South (Algarve)). Most of the fishery for this anchovy stock in the Division takes place in Sub-division IXa-South (C), where anchovy is the target species. The fleets in the northern part of Division IXa (targeting sardine) occasionally target anchovy when abundant, as occurred in 1995.

Data on number and technical characteristics for the Portuguese fleets are available for 2006 (ICES, 2007 a). The Portuguese purse- seine fleet (n =121 in 2006) presently ranges in size from 10.5 to 27 m (mean vessel length = 20 m) and between 71 to 447 HP (mean = 249) in vessel engine power. Portuguese producers organisations traditionally agree a voluntary closure of the purse-seine fishery in the northern part (north of the 39º 42" North) of the Portuguese coast. This closure usually lasted from the 1st of February to 31 of March. Since 2006, the closure, also lasting 2 months, may however be selected between 1st of February and 30th of April (*i.e.* boats stopped fishing in February to March or in March to April).

Since 1999 the number of Gulf of Cadiz purse-seiners operated by Spain has oscillated between 145 (in 2004) and 84 (in 2010) vessels, and the vessels within this fleet targeting anchovy between 76 (2010) and 135 (2004) vessels. As it has been previously reported (ICES, 2007 a), the observed fluctuations during this period were mainly motivated by the ending of the fifth EU-Morocco Fishery Agreement (in 1999, which affected the heavy-tonnage fleet in the following two years: acceptation of tie-up scheme in 2000 and 2001), the rising of the light-tonnage purse seiners on those dates, and the fluctuations showed by the multipurpose vessels. These vessels fishing for anchovy account for more than 85% of the whole fleet during the available series, evidencing the importance of anchovy as a target species in the Gulf of Cadiz purse-seine fishery. Since 2008 the EU–Morocco Fishery Agreement was renewed, and part of the fleet (the heavier/larger vessels) devoted to the anchovy fishing in the Moroccan grounds, which entailed an important reduction of the fishing effort in the Gulf of Cadiz.

A first attempt of identifying *métiers* in this last fleet/fishery was presented in the 2007 WGMHSA meeting (ICES, 2007 a). This study (see also Silva *et al*., 2007, for details) focused on the application of a non-hierarchical clustering data-mining technique (*CLARA*, *C*lustering *LAR*ge *A*pplications) for classifying the fishing trips from 2003 to 2005. The classification of individual trips was only based on the species composition of landings from logbooks, hence the preliminary character of this study. Up to four clusters (catch profiles) were identified from each of the annual datasets according to the targeted species: 1) trips targeting anchovy, 2) trips targeting sardine; 3) trips targeting a mackerel (*Scomber* spp.) species mixture; and 4) trips targeting an anchovy and sardine mixture. The first three groupings were considered as clearly identifiable *métiers* according to the knowledge on the fishery. At present no comparable information on Portuguese *métiers* is available.

The regulatory measures in place for the Spanish anchovy purse-seine fishing in this Division were the same as for the previous years and are summarized as follows:

- Minimum landing size: 10 cm total length;
- Minimum vessel tonnage of 20 GRT with temporary exemption;
- Maximum engine power: 450 h.p;
- Purse-seine maximum length: 450 m;
- Purse-seine maximum depth: 80 m;
- Minimum mesh size: 14 mm;
- Fishing time limited to 5 days per week, from Monday to Friday;
- Cessation of fishing activities from Saturday 00:00 hrs to Sunday 12:00 hrs;
- Fishing prohibition inside bays and estuaries.

Until 1997, the Spanish purse-seine fleet voluntary closed the fishery each year from December to February in the Gulf of Cadiz (Sub-division IXa-South(C)). Since 2004, two complementary sets of management measures have been in force in this part of the Sub-division. The first one is the new "*Plan for the conservation and sustainable management of the purse-seine fishery in the Gulf of Cadiz National Fishing Ground*". This plan is in force during 12 months from 30th October and includes a fishery closure (basically aimed to protect the anchovy recruitment) of either 45 days (between 17th of November to the 31st of December in 2004 and 2005), two months (November and December in 2006) or three months (mid November 2007 to mid February 2008; 1st December 2008 to 28th February 2009), accompanied by a subsidized tie-up scheme for the purse-seine fleet. The expected subsidized 3-month closure from 2009 mid-autumn to the 2010 mid-winter was restricted to one month only, in December 2009, although the fishery was practically closed since November 2009 until February 2010 for persistent bad sea conditions during all these months. This same scheme was accomplished for the 2010-2011 autumn/winter closure. This plan also includes additional regulatory measures on the fishing effort (200 fishing days/vessel/year as a maximum) and daily catch quotas per vessel (6000 kg of sardine-anchovy mixing, but the catch of each of these species cannot exceed 3000 kg). A new regulation approved in October 2006 establishes that up to 10% of the total catch weight may contain fish below the established minimum landing size (10 cm), but fish must always be ≥9 cm.

The effort exerted by the entire purse-seine fleet since 1997 has been high (even with the fishing closures since 2004 on). While the effects of the fishery closures have not been formally evaluated, it appears that they have limited a further expansion of effort.

The second management action in force since 15th of July 2004 is the delimitation of a marine protected area (fishing reserve) in the mouth and surrounding waters of the Guadalquivir river, a zone that plays a fundamental role as nursery area of fish (including anchovy) and crustacean decapods in the Gulf (**Figure A.2.1**). Fishing in the reserve is only allowed (with pertinent regulatory measures) to gill-nets and trammel-nets, although in those waters outside the riverbed. Neither purse-seine nor bottom trawl fishing is allowed all over this MPA. The effects of such closures and MPA in the Gulf of Cádiz anchovy recruitment are not still possible to be directly assessed. In any case, the implementation of both of these measures should benefit the stock.

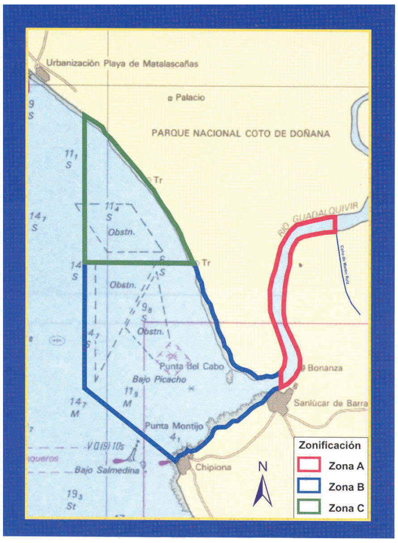

Figure A.2.1. Anchovy in Division IXa. Limits of the Fishing Reserve off the Guadalquivir river mouth (Spanish Gulf of Cadiz. Sub-division IXa South).

A.3. Ecosystem aspects

Anchovy is a prey species for other pelagic and demersal species, and for cetaceans and sea-birds. The recruitment depends strongly on environmental factors. Ruíz *et al.* (2006, 2007) evidenced the clear influence that meteorological and oceanographic factors have on the distribution of anchovy early life stages in shelf waters of the north-eastern sector of the Gulf of Cadiz. The shallowness of the water column, the influence of the Guadalquivir River, and the local topography favor the existence of warm and chlorophyll-rich waters in the area, thus offering a favorable environment for the development of eggs and larvae. However, spring and early summer easterlies bursts may cause: a) a decrease of the water temperature by several degrees, b) generate oligotrophic conditions in the area, and c) force the offshore transport of waters over this portion of the shelf, advecting early life stages away from favorable conditions. These negative influences on the development conditions of anchovy eggs and larvae can impact on the recruitment of this species in the Gulf of Cadiz and subsequently in the anchovy fishery.

The anchovy population in Subdivision IXa-South appears to be well established and relatively independent of populations in other parts of the Division. These other populations seem to be abundant only when suitable environmental conditions occur.

B. Data

B.1. Commercial catch

Portuguese annual landings from their respective Sub-divisions are available since 1943. Spanish landings started to be available since 1989.

No information on anchovy discarding in the Division IXa has been available until 2005. That year several pilot surveys for estimating discards in the Gulf of Cadiz Spanish fisheries (trawl, purse-seine and artisanal) were conducted by an IEO observer's programme onboard commercial vessels lasting five months and covering the whole study area. Preliminary results (average estimates from 6 purse-seine trips – 13 hauls –, not raised to total annual landings) from these pilot surveys were described in ICES (2006 a) although there were concerns about the reliability of such estimates and the ratios derived from them due to their extremely high associated CVs. On the other hand, discarded anchovies were of commercial and legal size, between 10 and 15 cm (mode at 12.5 cm), but reasons for discarding anchovy were not reported to that WG. Anchovy catches in sampled trips from the bottom otter-trawl fleet were negligible. Slipping practices are probable but not directly evidenced by sampling onboard. New data on anchovy discarding have started to be gathered since 2009 on within the Spanish National Sampling Scheme framed into the EC Data Collection Regulation (DCR).

B.2. Biological

Annual and quarterly length compositions of anchovy landings in Division IXa are routinely provided by Spain for its Sub-division IXa-South(C). This series dates back to 1988. Length distributions for the Spanish fishery in Sub-division IXa-North are only available for the 1995-1999 period and they were characterized, with the exception of 1998, by fish larger than 12.5 cm (ICES, 2007 a). At present, Portugal does not provide either length distributions or catches at age of their anchovy landings in Division IXa due to their scarce catches.

Catches at age from the whole Division IXa are only available from the Spanish Gulf of Cadiz fishery (Sub-division IXa South (C)). Problems with ageing/reading Gulf of Cádiz anchovy otoliths still persist.

The age composition of the Gulf of Cadiz anchovy in Spanish landings is available since 1988 (see ICES, 2007 a, for tabulated data from years not shown in this report). The catch-at-age series shows that 0, 1 and 2 age groups support the Gulf of Cadiz anchovy fishery and that the success of this fishery largely depends on the abundance of 1 year-old anchovies. The contribution of age-2 anchovies usually accounts for less than 1% of the total annual catch (except in 1997, 1999, the 2001-2003 period and since 2008 on, with contributions oscillating between 2% and 14%). Likewise, age-3 anchovies only occurred in the first quarter in 1992 and since 2008 on, but the importance of this age class in the total annual catch those years was insignificant. Inter-annual variations in the contribution of each age group in landings throughout the historical series are described in ICES (2007 a, 2008 a). Weights at age in the stock for the Gulf of Cádiz anchovy correspond to yearly estimates calculated as the weighted mean weights-at-age in the catches for the second and third quarters (throughout the spawning season).

Catches at age from the Spanish fishery in Sub-division IXa North are presently not available since commercial landings used to be negligible. Mean length- and mean weight-at-age data are only available for Gulf of Cadiz anchovy catches. The analysis of small samples of otoliths from Subdivision IXa North in 1998 and 1999 rendered estimates of mean sizes at ages 1, 2 and 3 of 15.5 cm, 17.6 cm and 17.9 cm respectively (ICES, 2000, 2001). A sample of 78 otoliths from the same area was collected during the *PELACUS 0402* acoustic survey. Mean lengths at age 1 and 2+ were 13.7 cm and 17.0 cm (Begoña Villamor, pers. comm.). Comparisons of these estimates with the ones from the Gulf of Cadiz anchovy indicate that southern anchovies attain smaller sizes at age.

Previous biological studies based on commercial samples of Gulf of Cadiz anchovy (Millán, 1999) indicate that its spawning season extends from late winter to early autumn with a peak spawning time for the whole population occurring from June to August. Length at maturity was estimated in that study at 11.09 cm in males and 11.20 cm in females. However, it was evidenced that size at maturity may vary between years, suggesting a high plasticity in the reproductive process in response to environmental changes. Annual maturity ogives for Gulf of Cadiz anchovy are routinely provided to ICES. They represent the estimated proportion of mature fish at age in the total catch during the spawning period (second and third quarters) after raising the ratio of mature-at-age by size class in monthly samples to the monthly catch numbers-at-age by size class.

Natural mortality is unknown for this stock. By analogy with anchovy in Sub-area VIII, natural mortality is probably high (M=1.2 is used for the data exploration).

B.3. Surveys

B.3.1. Acoustic surveys

The IPIMAR's Portuguese surveys series (*SAR* and *SARNOV* series, carried mainly out with the R/V *Noruega*) correspond to those ones routinely performed for the acoustic estimation of the sardine abundance in Division IXa off the Portuguese continental shelf and Gulf of Cadiz, during March-April (sardine late spawning season) and November (early spawning and recruitment season). Since 2007 on, the Spring surveys are being planned as 'pelagic community' surveys. This shift in planning mainly entailed, as compared with previous years, a substantial increase in the number of fishing stations in the Sub-division IXa-South, where the species diversity is higher, changing the series its former name by the one of *PELAGO* surveys. Anchovy estimates from these survey series started to be available since November 1998.

Spanish 'pelagic community' acoustic surveys have been conducted by IEO in Sub-division IXa North and Division VIIIc since 1983 (the spring *PELACUS* series with the R/V *Thalassa*). Results from these surveys for the Sub-division IXa North have shown the scarce presence or even the absence of anchovy in this area (Carrera, 1999, 2001; Carrera *et al*., 1999). This situation still continues in the most recent years (surveys in the 2003-2010 period, see Porteiro *et al*., 2005; Iglesias *et al*., 2007).

Spanish acoustic surveys in the Gulf of Cadiz waters (Sub-division IXa-South) have been sporadically conducted by IEO from 1993 to 2003. A consistent yearly series of early summer acoustic surveys (*ECOCÁDIZ* series) estimating the anchovy abundance in the Subdivision IXa South (Algarve and Gulf of Cadiz) started in 2004. Surveys in this new series are also planned under the 'pelagic community' approach. Unfortunately, this series may show some gaps in those years coinciding (same dates and surveyed area) with the conduction of the (initially triennial) anchovy DEPM survey because of the available ship time (R/V *Cornide de Saavedra*). In 2009 two additional surveys to the conventional one were also conducted, but mainly restricted to the Spanish waters. So, in July 2009 a complementary and almost synchronous survey to the *ECOCÁDIZ 0609* conventional survey was carried out with a small-draught vessel, R/V *Francisco de Paula Navarro*, aiming to survey shallower waters than 20 m depth not sampled by no vessel, either Spanish or Portuguese, routinely surveying the study area (*ECOCÁDIZ-COSTA 0709* survey). The acoustic estimates from this survey were separately given in the 2010 WG report from its conventional survey awaiting an intercalibration of data for a further merging of estimates if possible.

In October 2009 a new autumn survey (*ECOCÁDIZ-RECLUTAS 1009*, R/V *Emma Bardán*), aimed to acoustically estimate the abundance and biomass of Gulf of Cádiz anchovy recruits, was planned to be conducted throughout the easternmost Portuguese waters and those waters off the central part of the Spanish Gulf of Cádiz, waters that supposedly include the main Gulf of Cádiz anchovy recruitment area. Unfortunately, the shortness of the available ship-time to cover a more intensive acoustic sampling grid (*i.e.* 4 nm spaced transects from 100 to 7-10 m depth) than the conventionally planned in standard surveys and some other unforeseen circumstances (e.g., a one-day technical stop for crew replacement, 2-day military manoeuvres just in the middle of both the survey area and calendar) prevented finally from covering the whole survey area. For the above reasons, the surveyed area was restricted to a relatively small central area in front the Guadalquivir river mouth rendering a very probable underestimation of the recruits abundance. Continuity of this survey in following years will necessarily depend on external (EC) funding.

All these surveys followed the standard methodology adopted by the Planning Group for Acoustic Surveys in ICES Subareas VIII and IX (ICES, 1986; 1998) and recommendations given by the WGACEGG (ICES, 2006 b,c). The methodological differences between these recent surveys are not considered by the WGACEGG as important as to prevent from any comparison between their results, such differences being basically due to:

- • The echo-sounder and working frequencies used (IPIMAR surveys: Simrad EK 500 working at 38 and 120 KHz; IEO surveys since 2007 onwards: Simrad EK 60 working at 18, 38, 70, 120, and 200 KHz).
- • The fishing gear used as sampler for echo-trace identification/confirmation and gathering biological data (IPIMAR surveys: bottom and pelagic trawl gears; IEO surveys: pelagic trawl).
- • The software used for data storage and post-processing (IPIMAR surveys: Movies+ software; IEO surveys: SonarData EchoView software).
- • The set of species-specific TS-length relationships: at present, the new IPIMAR spring survey series, *PELAGOS*, takes into account the same agreed species-specific TS values than the IEO surveys, but for mackerel (b_{20} IPIMAR= – 82.0 vs b_{20} IEO= – 84.9).

Regarding their respective objectives, the *SAR* Portuguese November surveys, as presently planned, are mainly aimed at the mapping of the spatial distribution of sardine *Sardina pilchardus*, and anchovy *Engraulis encrasicolus*, and the provision of acoustic estimates of their abundance and biomass by length class and age groups, speciallly the computation of a sardine recruitment index (for the time being age-structured estimates are only available for sardine).

Although the main objective of the *ECOCÁDIZ* Spanish surveys was formerly the mapping and the size-based and age-structured acoustic assessment of the anchovy

SSB, and hence the survey's dates, mapping and acoustic estimates of all of those species susceptible of being assessed (according to their occurrence frequency and abundance levels in fishing stations) are also obtained. This same 'multi-species' or 'pelagic community' approach has also been adopted in the new *PELAGO* Spring Portuguese survey series, at least, for the time being, for the southern area (Subarea IXa South), which has involved a substantial increase in the number of fishing stations as compared with previous surveys. In any case, the progressive inclusion of alternative (continuous and discrete) samplers for collecting ancillary information on the physical and biological environment (including top predators) are shaping these surveys as true 'pelagic ecosystem surveys'.

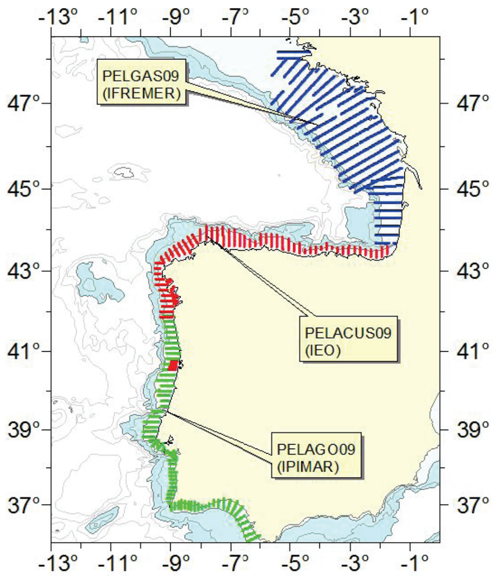

Figure B.3.1.1. Transects surveyed by the Spring *PELAGO*, *PELACUS* and *PELGAS* surveys. The early Summer *ECOCÁDIZ* surveys samples the same area that the *PELAGO* one in the Gulf of Cádiz waters (from Cape San Vicente to Cape Trafalgar).

B.3.2. DEPM Surveys

The Daily Egg Production Method (DEPM) for estimation of anchovy spawning biomass of the Gulf of Cádiz (South-Atlantic Iberian waters) is conducted every three years by IEO (Spain) since 2005. The first survey of this series was in 2005 (*BOCADEVA 0605*) and the second one in 2008 (*BOCADEVA 0608*). As described for the acoustic surveys, methods adopted for Gulf of Cádiz anchovy DEPM surveys follow the standards and recommendations given. **Figure B.3.2.1** shows the grid of egg sampling with the PairoVET sampler. **Table B.3.2.1** summarises the methodology used in these surveys (*BOCADEVA 0608* used as example) in order to obtain the eggs and adults samples.

Table B.3.2.1 *BOCADEVA 0608* Gulf of Cádiz anchovy DEPM survey. General sampling.

Parameters	**Anchovy DEPM survey *BOCADEVA0608***
Survey area	(36°18'- 36°75'N – 6°22'- 8°92'W)
R/V	*Cornide de Saavedra*
Date	21/06-03/07
Eggs	
Transects (Sampling grid)	21 (8x3)
Pairovet stations (150 µm)	127
Sampling maximum depth (m)	100
Hydrographic sensor	CTD SBE25 and CTD SBE37
Flowmeter	Yes
CUFES stations	121
CUFES (335µm)	3 nmiles (sample unit)
Environmental data	Fluorescence(surface only),Temperature, Salinity
Adults	
Gears	Pelagic trawl
Trawls	26
Trawls time	During the daylight hours
Biological sampling:	On fresh material, on board of the R/V
Sample size	60 indiv randomly (30 female minimum); extra if needed and if hydrated found
Fixation	Buffered formaldehyde 4% (distilled water)
Preservation	Formalin

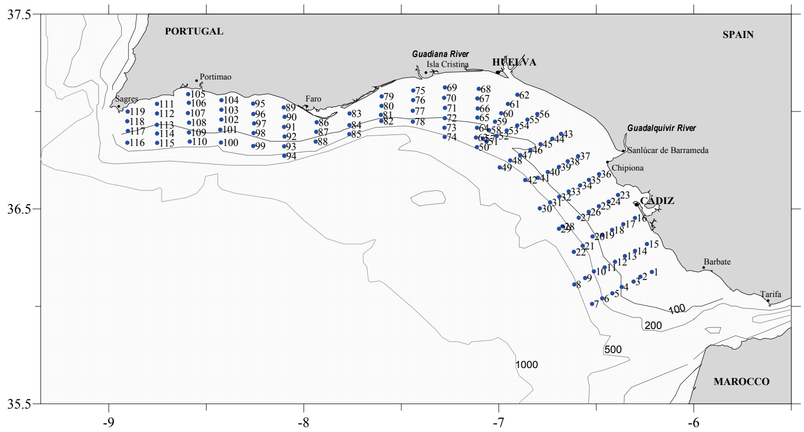

Figure B.3.2.1. Sampling grid adopted in the *BOCADEVA* anchovy DEPM surveys series.

Anchovy biomass estimation from these surveys was based on procedures and software adapted and developed during the WKRESTIM that took place between 27-30/04/2009 in Madrid (with e-participation of IPIMAR members from Lisbon), and validated by the WGACEGG. All calculations for area delimitation, egg ageing and model fitting for egg production (P_0) estimation were carried out using the R packages (*geofun, eggsplore and shachar*) available at *ichthyoanalysis* (http://sourceforge.net/projects/ichthyoanalysis). The surveyed area (*A*) was calculated as the sum of the area represented by each station. The spawning area (*A*+) was delimited with the outer zero anchovy egg stations, and was calculated as the sum of the area represented by those stations. The model of egg development with temperature was derived from the incubation experiment carried out in Cádiz in July 2007

(Duarte *et al*., 2007). A multinomial model was applied (Ibaibarriaga *et al.*, 2007, Bernal *et al.* 2008) considering only the interaction Age*Temp (other interactions were not significant). Egg ageing was achieved by a multinomial Bayesian approach described by Bernal *et al*. (2008) and using *in situ* SST; a normal probability distribution was used with peak spawning assumed to be at 22:00h with 2h standard deviation. This method uses the multinomial development model and the assumption of probabilistic synchronicity (assuming a normal distribution). Daily egg production (P_0) and mortality (z) rates were estimated by fitting an exponential mortality model to the egg abundance by cohorts and corresponding mean age. The model was fitted using a generalized linear model (GLM) with negative binomial distribution. The ageing process and the GLM fitting were iterative until the value of z converged. Finally, the total egg production was calculated as: $P_{tot} = P_0\, A+$

The adult parameters estimated for each fishing haul considered only the mature fraction of the population (determined by the fish macroscopic maturity data). Before the estimation of the mean female weight per haul (*W*), the individual total weight of the hydrated females was corrected by a linear regression between the total weight of non-hydrated females and their corresponding gonad-free weight (*Wnov*). The sex ratio (*R*) in weight per haul was obtained as the quotient between the total weight of females on the total weight of males and females. The expected individual batch fecundity for all mature females (hydrated and non-hydrated) was estimated by modelling the individual batch fecundity observed (*Fobs*) in the sampled hydrated females and their gonad-free weight (*Wnov*) by a GLM. The fraction of females spawning per day (*S*) was determined, for each haul, as the average number of females with Day-1 or Day-2 POF, divided by the total number of mature females (the number of females with Day-0 POF was corrected by the average number of females with Day-1 or Day-2 POF, and the hydrated females were not included). The mean and variance of the adult parameters for all the samples collected was then obtained using the methodology from Picquelle and Stauffer (1985; i.e., weighted means and variances). All estimations and statistical analysis were performed using the R software. The spawning biomass was computed according to:

$$SSB = \frac{P_0 * Area +}{(F * S * R)/W}$$

The high uncertainty associated to the estimates (especially to those ones related to the egg sampling in the 2005 survey) was matter of concern for the 2009 WGANSA and it was recommended that the appropriateness of the egg sampling scheme were revised in the 2009 WGACEGG. It was concluded by this last working group that reducing the variance in future surveys can probably be attained by increasing the number of stations in the actual positive spawning areas (adaptive sampling) and perhaps by applying GAM based estimators.

B.4. Commercial CPUE

The annual series of both nominal fishing effort (number of fishing trips) and CPUE indices of anchovy in Division IXa are available for the Gulf of Cadiz Spanish purse-seine fishery since 1988. The data series from the Spanish purse-seine fishery off southern Galician waters (Sub-division IXa North) only comprise the 1995-1999 period whereas no data from the Portuguese purse-seine fisheries along the Division are available. Causes for this scarcity or even absence of data from the later fisheries must be found in their low anchovy annual catches during the last 3-4 decades and mainly by the fact that these fisheries target sardine.

Regarding the Gulf of Cadiz anchovy Spanish fishery, data on annual values of nominal effort (fishing trips targeting on anchovy) and CPUE by fleet type have routinely been provided to ICES. The series of effective effort and CPUE from all of the Spanish fleets exploiting the Gulf of Cadiz anchovy were provided for the first time to the WGMHSA in 2004. For such a purpose, vessels from single-purpose fleets were additionally differentiated according to their tonnage in heavy- (≥30 GRT) and light- (<30 GRT) tonnage vessels, rendering a total of 11 fleet types.

The standardisation procedure was performed in the last years by fitting quarterly log-transformed CPUE's from fleet types composing the fishery to a GLM (Robson, 1966; Gavaris, 1980) which only included the effects of quarter and fleet type (without any interaction), (ICES, 2007 a). Since 2008 the GLM fitting is performed with the following modifications to the original version: (a) the effect of missing values in the nominal CPUE data was smoothed by adding a constant value to data before their log-transformation (ICES, 2008 b). In this case, this constant was computed as the 10% of the average value for the whole nominal CPUE series resulting in log(CPUE adjusted) data. (b) the model includes year, quarter, fleet type and first order interaction effects. Reference fleet (*métier* or fleet type), year and season used in the standardisation were the Barbate's single-purpose high-tonnage fleet, the first year in the series, 1988, and the first quarter in the year, respectively. The updated series of standardised effort and CPUE from all of the fleets exploiting the fishery is provided to the WG each year. Annual and half-year standardised CPUE series for the whole fleet are computed from the quotient between the sum of raw quarterly catches and that of standardised quarterly efforts within each of the respective time periods.

According to literature, CPUE indices have been considered, as not reliable indicators of abundance for small pelagic fishes (Ulltang, 1982, Csirke 1988, Pitcher 1995, Mackinson *et al.* 1997). At present, the series of CPUE indices is only used for interpreting the fleet's dynamics.

B.5. Other relevant data

C. Historical Stock Development

Model used:

For the time being, no analytical assessment model has been successfully applied. An exploratory assessment was under development until 2008. This exploratory assessment carried out so far was only performed for the anchovy population nucleus in the Gulf of Cádiz (Sub-division IXa-South: Algarve + Cádiz zones), the remaining resilient anchovy populations along the Atlantic Iberian façade of the Division being out of the scope of this assessment. The model used was an *ad hoc* seasonal separable model implemented and run on a spreadsheet for data exploration of anchovy catch-at-age data in IXa South since 1995 onwards. Given the nature of stock, short-lived, data in this model were analysed by half-year-periods, those from the Algarvian anchovy being previously compiled by applying Gulf of Cadiz ALKs. Weights at age in the catches were estimated as usual, whereas weights at age in the stock corresponded to yearly estimates calculated as the weighted mean weights-at-age in the catches for the second and third quarters (reproductive season). The model was fitted to the updated half-year catch-at-age data until the assessment's last year and to the available acoustic estimates of anchovy aggregated biomass from the spring Portuguese surveys series only (including the acoustic estimate one year ahead of the assessment's last year).

Reasons for the choice of the above tuning index were: (a) the Spanish acoustic survey series (2004, 2006, 2007), was not used as a tuning index because of its shortness; (b) neither the DEPM-based anchovy SSB was considered since it has only 1 data point until the last year, but it was provided for comparison with the acoustic and model-predicted biomass estimates; (c) both Portuguese acoustic surveys series (spring and autumn surveys) were used as tuning indices in the past, assuming the same catchability coefficient. However, each survey series cover different fractions of the population so, the assumption of same catchability is probably inappropriate. Given that the model is unlikely to be able to estimate the extra parameter and that the spring survey series has a better coverage both in space and time, only this survey series was recently used.

The exploratory runs were recently performed under the following assumptions:

–Assessment only tuned by Spring Portuguese acoustic surveys (for the reasons above).

–Catches at age are assumed by the model to be linked by the Baranov catch equations.

–The relationship between the index series and the stock sizes is assumed linear.

–A constant selection pattern is assumed for the whole period.

–F values for 1995 (assessment's first year) are computed as an average of the Fs in subsequent years.

–F in the 2nd half-year in the assessment's last year estimated as a ratio of the F estimated in the 1st half by applying the ratio of seasonal Fs in the previous year (affected by a closure as well in the last years).

–No available Cages for the first half in the year ahead of the assessment's last year: assumed as the same ones that in first half in the assessment's last year.

–Wagesstock in the year ahead of the assessment's last year: average of the estimates in the 3 last years in the assessment.

–F in the 1st half year of the assessment's last year: average of estimated 1st half-year Fs counterparts for the same period of years.

– Log-residuals of Cages in the year ahead of the assessment's last year excluded from the minimisation routine whereas the residuals from the biomass acoustic estimate in the year ahead of the assessment's last year are included in the model fitting.

Runs explored last years consisted in:

- **RUN 1**: Acoustic surveys as a relative tuning index and a weighting factor= 1.
- **RUN 2**: Acoustic surveys as a relative tuning index and a weighting factor= 6.
- **RUN 3**: Acoustic surveys as an absolute tuning index and a weighting factor= 1.

An upweighting factor of 6 for the acoustic estimates in RUN 2 was selected in order to balance the influence of their annual residuals in relation to those from catches at age (3 age groups x 2 semesters in a year). The rational for RUN 3 is the similarity between the estimates by the Portuguese survey and the Spanish DEPM in 2005 (around 14,000 tonnes).

Parameters estimated are selectivity at age for both half-year-periods in relation to the reference age (age 1), recruitment, an average SSB, survey catchability (Q) and annual F values per half-year-period. Parameters are estimated by minimising the sum of squares of the log-residuals from the catch-at-age and the acoustics biomass data.

The exploratory assessments performed so far with this *ad hoc* model have not been recommended as a basis for predictions or advice. The immediate reason is that it usually estimated a large drop in fishing mortality and rapid increase in stock abundance in recent years, which is not supported by the data or the development of the fishery. The residuals showed large clusters over time, indicating that the selection may not be constant, one of the model's assumptions. Migration between the main nucleus in the Gulf of Cádiz and adjacent areas might be one of the causes explaining the discrepancies found in the assessment and it should be properly studied. The exploratory model utilised so far does not provide any reliable information about the true levels of both the stock, F and Catch/SSB ratios since the assessment is not still properly scaled.

For all the above reasons in 2009 was preferred to do not perform any exploratory assessment with this model. Instead of this, the provision of advice relies in an update of the qualitative assessment carried out in 2008 and accepted by the Review Groups of the 2008 and 2009 WGANC (RGANC). This qualitative assessment is based on the joint analysis of trends showed by the available data, both fishery-dependent and –independent information (*i.e.*, landings, fishing effort, cpue, survey estimates).

Advice is framed in a precautionary manner to limit exploitation and, accordingly, the basis for advice is average catches over a reference period.

Software used: the exploratory model was implemented and run in a MicroSoft Excel spreadshet.

Model Options chosen:

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes			
Canum	Catch at age in numbers			
Weca	Weight at age in the commercial catch			
West	Weight at age of the spawning stock at spawning time.			
Mprop	Proportion of natural mortality before spawning			
Fprop	Proportion of fishing mortality before spawning			
Matprop	Proportion mature at age			
Natmor	Natural mortality			

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1			
Tuning fleet 2			
Tuning fleet 3			
….			

D. Short-Term Projection

Model used:

Software used:

Initial stock size:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock recruitment model used:

Procedures used for splitting projected catches:

E. Medium-Term Projections

Model used:

Software used:

Initial stock size:

Natural mortality:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock recruitment model used:

Uncertainty models used:

1. Initial stock size:

2. Natural mortality:

3. Maturity:

4. F and M before spawning:

5. Weight at age in the stock:

6. Weight at age in the catch:

7. Exploitation pattern:

8. Intermediate year assumptions:
9. Stock recruitment model used:

F. Long-Term Projections

Model used:

Software used:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Procedures used for splitting projected catches:

G. Biological Reference Points

H. Other Issues

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A.5.3 Stock Annex – Sardine in Division VIIIc and IXa (Sar-Soth)

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Sardine in Divisions VIIIc and IXa (sar-soth).
Working Group:	**WGHANSA**
Date:	February 2012
Revised by:	WKPELA 2012

A. General

A.1. Stock definition

European sardine (*Sardine pilchardus* Walbaum, 1792) has a wide distribution extending in the Northeast Atlantic from the Celtic Sea and North Sea in the north to Mauritania in the south. Populations of Madeira, the Azores and the Canary Islands are at the western limit of the distribution (Parrish *et al*., 1989). Sardine is also found in the Mediterranean and the Black Seas. Changing environmental conditions affect sardine distribution, with fish having been found as far south as Senegal during episodes of low water temperature (Corten and van Kamp, 1996; Binet *et al*., 1998).

The sardine stock assessed by ICES covers the Atlantic waters of the Iberian Peninsula (ICES Areas VIIIc and IXa), extending from the Strait of Gibraltar in the south to the border with France in the Inner Bay of Biscay in the north. These limits are somewhat arbitrary in that they were set for management purposes (Figure A.1).

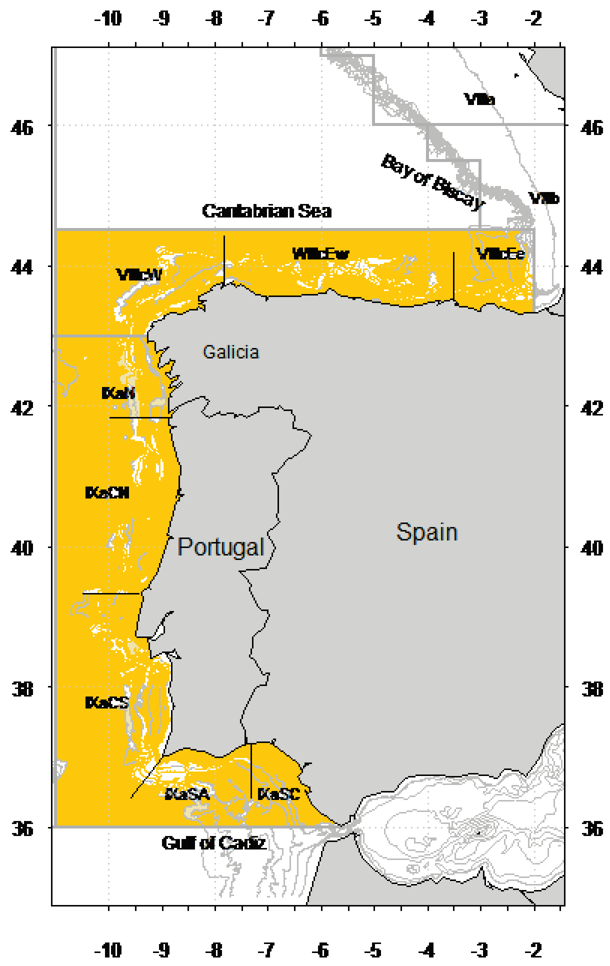

Figure A.1. Map of the current Iberian sardine stock area showing (in orange) the ICES Divisions and subdivisions currently considered in the assessment of the stock.

Because sardine distribution is continuous in the Northeast Atlantic (from the Agadir area in north Morocco to the North Sea) it is likely that there could be movement of fish to and from the stock area and it is the level and impact of this movement which is relevant for the assessment of sardine in Iberian waters. Several genetic studies have failed to demonstrate population differentiation inside the area, with only weak population structure being found using allozymes (Laurent *et al.*, 2007, Figure 2) and microsatellite DNA (Kasapidis *et al.*, 2012). These studies also reported that sardine taken from Azores and Madeira was genetically closer to Mediterranean samples than to those sampled in other areas of the Northeast Atlantic.

Common genetic and life-history characters provide indication of the possibility of some mixing across the southern Iberian stock limit (Gulf of Cádiz) with sardine populations from southwest Mediterranean and northern Morocco. However, the absence of large sardine populations in these areas would limit the influence of such movements in the dynamics of the Iberian stock.

There are also indications of spatial population substructuring across Iberian waters. Although sardine shows a nearly continuous spawning ground distribution along the Iberian and French Atlantic coasts (Bernal *et al.*, 2007), there some evidence of distinct recruitment pulses off the two main recruitment areas in some years (northern Portugal and the Gulf of Cádiz) and observation that these mainly influence the demography of adjacent populations but not that of distant ones (Silva *et al*., 2009; Riveiro *et al*., 2012 WD). Persistent spatial differences in growth (Silva *et al*., 2008) and spawning temperature tolerance have also been found (Stratoudakis *et al*., 2007) and these together with the existence of a persistent gap (Bernal *et al*., 2007) in the spawning area corroborate the hypothesis of spatial heterogeneity of sardine populations. However, indirect evidence of movements from otolith chemistry (Castro, 2007) and cohort analyses (Sardyn project report) suggest that sardines recruiting on the western area move gradually north or south as they grow, crossing the above potential discontinuities.

Catch and survey-at-age data appear to indicate that some strong year classes in the Cantabrian Sea (VIIIc East) originated from recruitment areas in the Gulf of Biscay (VIIIa,b) (Riveiro *et al*., 2012WD). Furthermore, the northern extent of this homogeneous population is still unclear. Sardine maturity-at-length seems to decline substantially in northern France while growth might increase in the English Channel (Silva *et al*., 2008a). Young sardine are not usually observed in this northern area (although juveniles have been recently sampled in the North Sea), suggesting that older (2+) spawning individuals from the English Channel possibly originate in the French coast. Microsatellite analyses revealed no significant genetic differentiation among sardines in Subarea VII and VIII (Shaw *et al.*, 2012). The inner Bay of Biscay does not represent a barrier for other small pelagic fish populations either; as horse mackerel, anchovy and mackerel stocks are also considered to distribute across the Cantabrian Sea and Gulf of Biscay (Abaunza *et al*., 2008; Uriarte *et al*., 1996, 2001). No other barriers were evidenced within French Atlantic waters for any of these species.

In recent years there has been an increase of sardine in both the commercial landings and in fishery-independent surveys in the Celtic Sea and western Channel (VIIe–j) (Beare *et al*., 2004) and is forming the basis of a locally important fishery (Cornish sardine) (ICES, 2010).

Further efforts should help to clarify sardine population structure in this area and their relationship with fish in the Bay of Biscay and the Iberian sardine stock, in order to take into account regional dynamics in the context of an area based assessment.

A.2. Fishery

The bulk of the landings in both Spain and Portugal (99%) are made by purse-seiners.

The Spanish purse-seine fleet targets anchovy (*Engraulis encrasicolus*), mackerel (*Scomber scombrus*) and sardine, (which occur seasonally in the area) and horse-mackerel (*Trachurus trachurus*) which is available all year-round (Uriarte *et al*., 1996; Villamor *et al*., 1997; Carrera and Porteiro, 2003). In summer, part of the fleet switches to trolling lines or bait boat for tuna fishing, a resource with a marked seasonal character. Since 2004, Spanish legislation requires that purse-seiners must have, at least, a length of 11 m in the Atlantic coast of Spain. Moreover, the gear must have a maximum length of 600 m, a maximum height of 130 m and minimum mesh size of 14 mm (see Table A.2.1). Because of this regulation, most of the effort and catches are registered in logbooks (which are mandatory for boats larger than 10 m). Analysis of these logbook data from 2003 to 2005 (Abad *et al.*, 2008) showed that currently, sardine and horse-mackerel represent 75% of the total landings of the purse-seine fleet, which is in accordance with the values observed in historical series of purse-seine catch statistics, especially when the anchovy is scarce (ICES, 2007). Sardine catches show the highest values in summer and autumn and effort concentrates in southern Galician and western Bay of Biscay waters. Vessels can be characterized by 21 m length overall, 296 HP, and 57 gross tonnage.

In Portugal, sardine is the main target species of the purse-seine fleet comprising 98% of the landings. The sardine fishery is of great social-economical importance for the fishing community and industry since it represents an important part of the fish production and a relevant supply for the canning sector. Other pelagic species such as chub mackerel (*Scomber japonicus*), horse mackerel and anchovy are also landed by the purse-seine fishery. Currently, purse-seiners in Portuguese waters have a length of about 20 m; an engine horsepower between 100 and 500 HP and use a minimum mesh size of 16 mm (see Table A.2.1). According to Stratoudakis and Marçalo (2002), fishing is usually close to the home port, on short (daily) trips where the net is set once or twice, usually around dawn. A large part of a typical fishing trip is spent searching for schools with echosounders and sonars. Once schools of pelagic fish have been detected, large nets (up to 800 m long and 150 m deep) are set rapidly with the help of an auxiliary small vessel, and hauled in a largely manual operation involving all members of the crew (usually between 15–20 people) (Mesquita, 2008).

Table B.2.1. Summary of the major existing regulatory mechanism for sardine.

Species	Technical measure	National/European level	Specification	Note	Source/date of implementation
Sardine	Minimum size	European	11 cm	10% undersized allowed	EU Reg 850/98 amended 1999, 2000, 2001, 2004
Sardine/Anchovy	Effort limitations	National (ES)	VIIIc,IXa: minimum vessel tonnage 20 GRT, maximum engine power 450 hp, max length purse-seine 450 m, max height purse-seine 80 m, minimum mesh size 14 mm, max number of fishing days/week: 5, fishing prohibited in bays and estuaries Gulf of Cádiz: Maximum net length 450 m. Maximum net high 80 m.		1997
Sardine	Catch limitation	National (ES)	Max 7000 kg/day/boat fish >15 cm, max 2000 kg/day/boat fish between 11 and 15 cm. IXaS Cádiz: 3000 kg/vessel day(<10% of small sardine (<9 cm))		1997
Sardine/anchovy	Area closure	National (ES)	IXaS Cádiz: fishing closures implemented annually between November–February		2008
Sardine/Anchovy	Effort limitations	National (PT)	IXa: max length of purse-seine 800 m, max height of purse-seine 150 m, max number of fishing days/week: 5, max number of fishing days/year: 180	Portaria n.o 1102-G/2000 de 22 de Novembro	1997

Species	Technical measure	National/European level	Specification	Note	Source/date of implementation
Sardine/Anchovy	Area closure	National (PT)	No purse-seine fishing at depths lower than 20 m. For 2012, there is a 45 day fishing ban for sardine for all regional PO, in alternate periods between 15 February and 30 April.	Despacho n.º 1521/2012, 1 February 2012	1997
Sardine	Catch limitation	National (PT)	55 thousand tons January–May 2012: 9 thousand tons	Applicable to vessels associated under PO (Producer Organization) which make 96% of the landings. Non-associated vessels have equivalent restrictions.	2010
All species	Mesh sizes	European	different specifications acc. to catch compositions	In Portugal, >16 mm, Portaria n.o 1102-G/2000 de 22 de Novembro	EU Reg 850/98 amended 1999, 2000, 2001, 2004
All species	Mesh openings	European	different specifications acc. to catch compositions		EU Reg 850/98 amended 1999, 2000, 2001, 2004

A.3. Ecosystem aspects

There are a number of studies investigating the role of sardine in the ecosystem both as predator and prey. Sardine is widely distributed all along the Atlantic Iberian shelf in waters ranging from 10 to 100 m (e.g. Porteiro *et al.*, 1996). Analysis of its stomach contents and stable isotope signature indicate an omnivorous feeding behaviour, related to its ability to feed by particle-feeding and filter-feeding (more common as fish grow older, Bode *et al.*, 2003), and its exploitation of a wide range of prey (both phytoplankton and zooplankton have been found in its diet, e.g. Bode *et al.*, 2004). In addition, sardines have been found to ingest their own eggs (and probably those of other species) and this cannibalism may act as a density control mechanism (Garrido *et al.*, 2007).

The composition of nitrogen isotopes in the muscle of sardine integrates fish diet over seasonal periods and reflects the composition of plankton over large shelf areas. A differential isotopic signature in high and low upwelling zones reflects low mobility of sardines during periods of low population size (Bode *et al.*, 2007).

Sardine is prey of a range of fish and marine mammal species which take advantage of its schooling behaviour and availability. Sardine has been found to be important in the diet of common dolphins (*Delphinus delphis*) in Galicia (NW Spain) (Santos *et al.*, 2004), Portugal (Silva, 2003) and the Atlantic French coast (Meynier, 2004). Recent studies of consumption of common dolphins in Galician (Santos *et al.*, 2011b) waters give figures ranging from almost 6000 tons to more than 9000 tons of sardine, which represents a rather small proportion of the combined Spanish and Portuguese annual landings of sardine from ICES Areas VIIIc and IXa (6–7%).There are also other species feeding on sardine, although to a lesser extent, such as: harbour porpoise (*Phocoena phocoena*), bottlenose dolphin (*Tursiops truncatus*), striped dolphin (*Stenella coeruleoalba*), and white-sided dolphin (*Lagenorhynchus acutus*) (e.g. Santos *et al.*, 2007).

Habitat modelling studies aim to identify which environmental processes could be defining the habitat of a species and eventually to be able to predict fish distribution. Zwolinski *et al*. (2008) analysed the relationship between data on sardine distribution obtained by the Portuguese acoustic surveys and four environmental variables (subsurface salinity, temperature, chlorophyll concentration and plankton presence). Sardine showed a preference for waters with low temperature and salinity, high chlorophyll content and low planktonic backscattering energy.

Populations of planktivorous fish, such as the sardine, show large fluctuations in size and distribution over the Atlantic Iberian shelf (Carrera and Porteiro, 2003). Periods of good recruitments have helped develop new industries and led to the social and economic changes while periods of continuous low recruitments have brought economic hardship in many areas. This was the case of the Iberian sardine at the end of the 1990s, when several successive poor recruitments led to an all time low of the stock biomass. Sardine is a batch spawner producing batches of eggs over an extended period of time (October to May) in Iberian waters with different peaks between southern and northern regions. Although the survival of offspring is highly dependent on favourable environmental conditions (concentrations of egg/larvae in suitable areas), sardine appears to show a wide range of temperature tolerance for both habitat and spawning distribution (Bernal, 1998). Even more, the presence of sardine larvae has been recorded by a recent study (Morais *et al.*, 2009) inside the Guadiana estuary. The authors suggest that this is not an accidental occurrence but that in order to migrate to that location and remain in the estuary, counteracting river inflow, these late larvae must have employed active migration and retention strategies.

Upwelling intensity was shown to affect both positively and negatively sardine recruitment (Dickson *et al.*, 1988; Roy *et al.*, 1995) but the main direct effect was due to the transport of eggs and larvae offshore by northern winds (Guisande *et al.*, 2001). In this way, strong upwelling during the recruitment season would decrease the probability of survival of sardine larvae as they are dispersed to outer shelf and oceanic zones. In contrast, southerly winds favour the progress of the poleward current, and tend to accumulate fish larvae near the coast where plankton biomass and production are high. At high population sizes, sardine spawning and distribution areas extend over the whole continental shelf and the adults display feeding migrations to the upwelling area off Galicia, while at low population sizes a reduction in the mobility of adult sardines between the Cantabrian Sea and Galicia is expected (Carrera and Porteiro, 2003).

Santos *et al*. (2011a) analysed previous studies, on relationships between recruitment and environmental variables for the sardine around the Iberian Peninsula and carried out a new analysis of empirical relationships with environmental series, using dynamic factor analysis, generalized additive models, and mixed models. Relationships were identified between recruitment and global (number of sunspots), regional (NAOAutumn), and local winter wind strength, sea surface temperature (SST), and upwelling environmental variables. Separating these series into trend and noise components permitted further investigation of the nature of the relationships. Whereas the other three environmental variables were related to the trend in recruitment, SST was related to residual variation around the trend, providing stronger evidence for a causal link. After removal of trend and cyclic components, residual variation in recruitment was also weakly related to the previous year's spawning–stock biomass.

B. Data

B.1. Commercial catch

Commercial catch data are obtained from the national laboratories of both Spain and Portugal. Annual landings are available since 1940 (see Figure B.1). Landings are not considered to be significantly underreported.

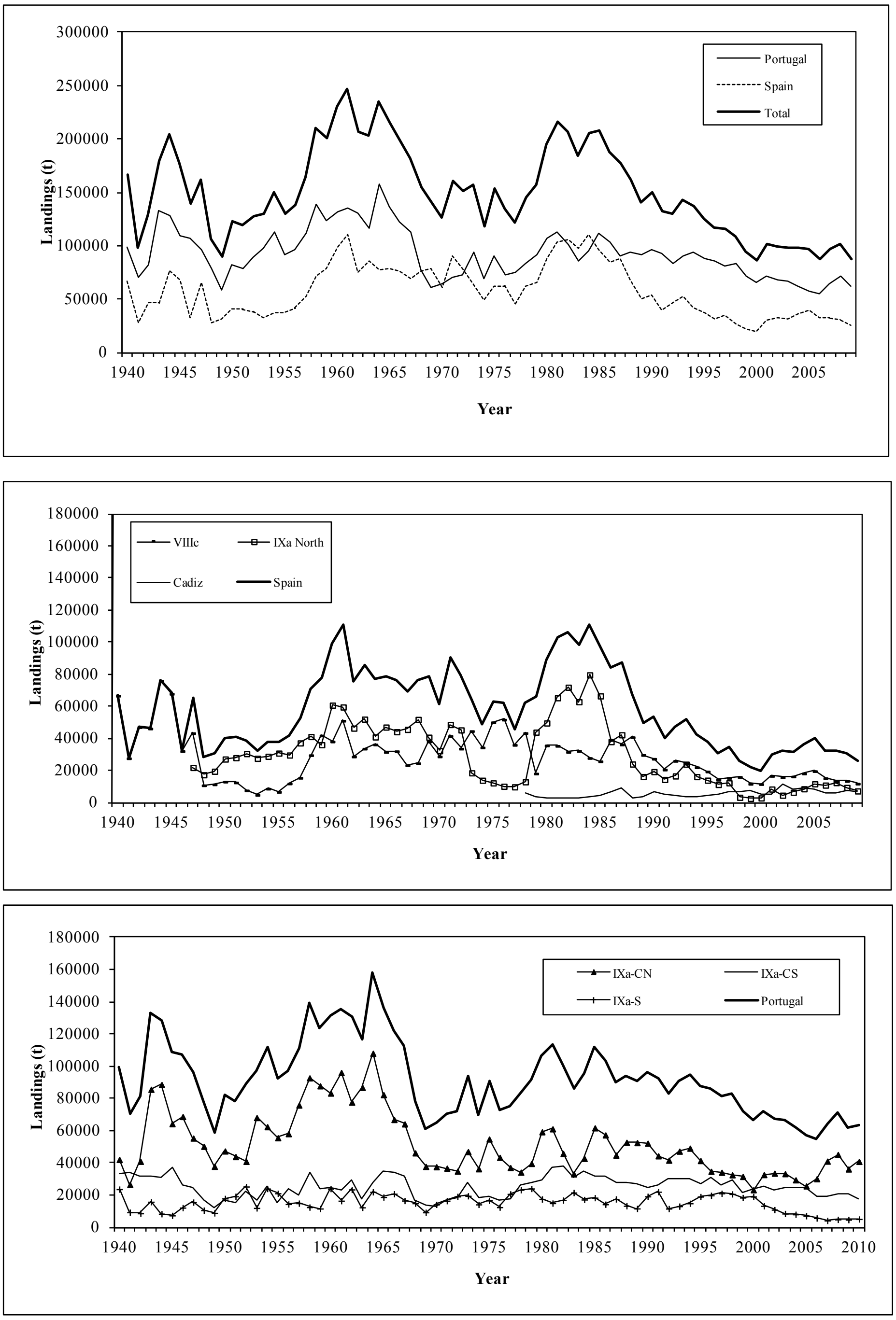

Figure B.1. Annual landings of sardine, by country and area.

Discards data on the fishery are not available and it is very difficult to measure. As with other pelagic fisheries that exploit schooling fish discarding occurs in a sporadic way and with often extreme fluctuation in discard rates (100% or null discards). Extreme discards occur especially when the entire catch is released ("slippage") which tend to be related to quota limitations, illegal size and mixture with unmarketable bycatch. Quantifying such discards at a population level is extremely difficult because they vary considerably between years, seasons, species targeted and geographical region.

A discard programme, sampling purse-seine vessels, has started in Portugal. Nevertheless, discard estimates are still not available. There is some slipping in northern

Portugal (Division IXa) but mostly in years with high recruitment. During a twelve week lasting study, the sampled fleet (nine vessels) landed 2196 t and released an estimated 4979 t (CV 33.6%) (Stratoudakis and Marcalo, 2002). More than 95% of the total catch was sardine.

Sardine constituted 97% of the landings in the trips observed and >99% of the total for the whole fleet, and some of the bycatch species caught in small quantities during the trips observed never reached the market.

Since 1999 (catch data 1998), both Spanish and Portuguese laboratories have used a common spreadsheet to provide all necessary landing and sampling data developed originally for the Mackerel Working Group (WGMHSA). The stock co-ordinators collates data using the latest version of SALLOCL (Patterson, 1998) which produces a standard output file (Sam.out). However it should be noted that only sampled, official, WG catch and discards are available in this file.

In addition, commercial catch and sampling data were stored and processed using the InterCatch software for the first time during the WGHMHSA in 2007. Comparisons were made between the SALLOCL and the InterCatch routines and a very good agreement was found (<0.3% discrepancies). These discrepancies are likely the results of the fact that for stocks where no allocations are required (as is the case of sardine), the SALLOCL application requires a 'dummy' allocation to be made in order for the program to run successfully. While a very small value is used for the allocation, it is likely to have some impact on the results and so will have added to the discrepancy when compared with the InterCatch output.

B.2. Biological

Catch-at-age data (catch numbers-at-age, mean weights-at-age in the catch, mean length-at-age) are derived from the raised national figures routinely provided by both Spain and Portugal. These data are obtained either by market sampling or by on-board observers. In Spain, samples for age–length keys are pooled on a half year basis for each subdivision while length–weight relationships are calculated quarterly. In Portugal, both age–length keys and length–weight relationships are compiled on a quarterly and subdivision basis.

Mean weights-at-age in the stock are derived from March/April acoustic surveys and maturity ogive comes from DEPM surveys, whilst for the years without DEPM surveys, a constant value of 80% full maturity-at-age 1 and a 100% for ages 2 and older is adopted. The 80% maturity-at-age 1 is about a median of former DEPM estimates.

Table B.2.1. Summary of the overall sampling intensity over recent years on the catches of the sardine stock in VIIIc and IXa.

Year	Total catch	N° samples	N° fish measured	N° fish aged
1992	164 000	788	66 346	4086
1993	149 600	813	68 225	4821
1994	162 900	748	63 788	4253
1995	138 200	716	59 444	4991
1996	126 900	833	73 220	4830
1997	134 800	796	79 969	5133
1998	209 422	1372	123 754	12 163
1999	101 302	849	91 060	8399
2000	91 718	777	92 517	7753
2001	110 276	874	115 738	8058
2002	99 673	814	96 968	10 231
2003	97 831	756	93 102	10 629
2004	98 020	932	112 218	9268
2005	97 345	925	116 400	9753
2006	87 023	927	122 185	9165
2007	96 469	797	97 187	8607
2008	101 464	821	91 847	7950
2009	87 740	465	52 821	8216
2010	89 572	327	35 615	7890

B.3. Surveys

At present, the surveys used in the sardine assessment are the Spanish and Portuguese DEPM surveys and the spring acoustic surveys which jointly provide a full coverage of the stock area (ICES Areas VIIIc and IXa). Surveys not used in the assessment, which cover parts of the stock area or Areas VIIIa,b (considered to be a different stock unit) are also described below for completeness.

B.3.1. DEPM surveys

The Daily Egg Production Method started being applied to sardine in the Iberian Peninsula during the 1980s but surveys were interrupted for almost ten years. Current DEPM surveys started in 1997 for both Spain and Portugal and have been carried out triennially since 1999. Sampling design and methodology have been further standardized in 2002 in order to guarantee good coordination of the surveys and analyses of the data collected Since 2011 the coordinated surveys between Spain (IEO and AZTI) and Portugal (IPIMAR) do also cover the Bay of Biscay (Divisions VIIIa, b).

The extension of the surveyed area almost up to Southern Brittany results in a complete coverage of the species over most of its European Atlantic distribution (Subareas IX and VIII), except for the top Northwestern limits. The methodology adopted for the processing of sardine adults data followed the general plan agreed for previous surveys (cf. ICES, 2005, 2006 and 2007) and a summary is presented in Table B.3.1.

Table B.3.1. Processing and analysis for eggs and adults (The surveys carried out by IEO and AZTI cover Areas VIIIb and VIIIa,b, respectively).

DEPM	Portugal (IPIMAR)	Spain (IEO)	Spain (AZTI)
EGGS			
PairoVET eggs staged sardine (Gamulin & Hure, 1955)	All	All	Sample size 50/75 or all eggs
CUFES egg staged sardine (Gamulin & Hure, 1955)	In the lab, all or subsample if more than 100 per sample	No	No
Temperature for egg ageing	Surface (continuous underway CTF at 3 m)	10 m	10 m
Peak spawning hour	21:00 (Sd=3 hh)	21:00 (Sd=3 hh)	21:00 (Sd=3 hh)
Egg ageing	Bayesian (Bernal *et al.*, 2008)	Bayesian (Bernal *et al.*, 2008)	Bayesian (Bernal *et al.*, 2008)
Egg production	GLM (and GAMs available)	GLM (and GAMs available)	GLM (and GAMs available)
ADULTS			
Histology -Embedding material	Paraffin	Resin	Resin
-Stain	Haematoxilin-Eosin	Haematoxilin-Eosin	Haematoxilin-Eosin
S estimation	Day 1 and Day 2 POFs (according to Pérez *et al.*, 1992a and Ganias *et al.*, 2007)	Day 1 and Day 2 POFs (according to Pérez *et al.*, 1992a and Ganias *et al.*, 2007)	Day 1 and Day 2 POFs (according to Pérez *et al.*, 1992a and Ganias *et al.*, 2007)
R estimation	The observed weight fraction of the females	The observed weight fraction of the females	The observed weight fraction of the females
F estimation	On hydrated females (without POFs), according to Pérez *et al.*, 1992b	On hydrated females (without POFs), according to Pérez *et al.*, 1992b	On hydrated females (without POFs), according to Pérez *et al.*, 1992b

B.3.2. Acoustic surveys

B.3.2.1 Spring acoustic Surveys

Portuguese and Spanish acoustic surveys are coordinated within WGACEGG (ICES, 2011). Surveys are undertaken within the framework of the EU DG XIV project "Data Directive". There are two spring annual surveys (one Portuguese and one Spanish) used in the assessment as a single index of abundance of the stock. During the benchmark assessment carried out in 2006, a joint survey dataseries was made as a weighted sum of the two spring surveys and results from the exploration of survey data provided some indication of similar catchabilities. In addition, preliminary runs with a range of weighting factors the Spanish surveys indicated that the actual catchability ratio made little difference to the final outcome of the assessment. Therefore, the stock was assessed with a joint spring survey derived by just adding the Spanish and the Portuguese results. In spite of this, the merging of data from these surveys remains an outstanding issue in the current assessment and in order to address this, two calibration exercises between the Spanish and Portuguese acoustic surveys have taken place in spring 2008 and again in 2009 with the simultaneous coverage of several transects by the RVs Thalassa (Spanish survey) and Noruega (Portuguese survey) off northern Portugal. Results from these exercises were inconclusive and therefore a new intercalibration is planned in 2012. Conclusions will be analysed within WGACEGG.

In addition to the spring surveys, between 1984 and 2008 (gaps in 1988–1991 and 1993–1996) there was a Portuguese acoustic survey carried out in November and covering the Portuguese waters and, since 1997, the Gulf of Cádiz. This survey follows the same methodology as the spring surveys and is also coordinated by WGACEGG. Since it covers only part of the stock area and may not take into account changes in distribution between years, it is currently not used in the assessment model. However, it covers the main recruitment areas of the stock and is therefore used as additional information on recruitment strength. This survey-series could be potentially useful in the context of a future area-based assessment.

Outside the assessed stock area, the spring acoustic survey PELGAS (run by Ifremer) covers the area from the south of the Bay of Biscay to south of Brittany (Figure B.3.2.1.3).

B.3.2.1.1. Portuguese spring acoustic survey: PELAGOS

The Portuguese acoustic surveys (on board the RV “Noruega”) are mainly directed to sardine and anchovy.

The survey track follow a parallel grid, with transects perpendicular to the coastline. The acoustic energy in the inter-transect track is not taken into account. The transects are spaced by 8 nautical miles in the West Coast, 6 nautical miles in Algarve and around 10 nautical miles in the Cádiz area. Acoustic data from 38 kHz is stored with MOVIES+ software as standard HAC files along the transects. Trawl hauls are performed whenever significant amounts of fish are found but mainly targeting sardine and anchovy. Trawl data are used to:

- Identify the echotraces
- Obtain the length structure of the population
- Obtain the species proportion
- Get biologic samples

The identification of the echotraces is made by eye, with the aid of the trawl hauls. If it is not possible to separate the species schools by eye, the energy of the ESDUs (Elementary Sampling Distance Unit) is split using the haul species proportion, in number, and taking into account the target strength and the species length compositions.

The weight of the hauls is always the same, since a post stratification is made and the overall area is divided into small homogeneous areas, with similar length composition. To partition the acoustic energy by species, using the trawl species proportion, the hauls are not weighted by the energy around the haul, assuming that the species mixture is independent of the acoustic energy density. The acoustic energy is extracted from the EK500 echograms, school by school, using MOVIES+ software. Plankton and very small schools are rejected.

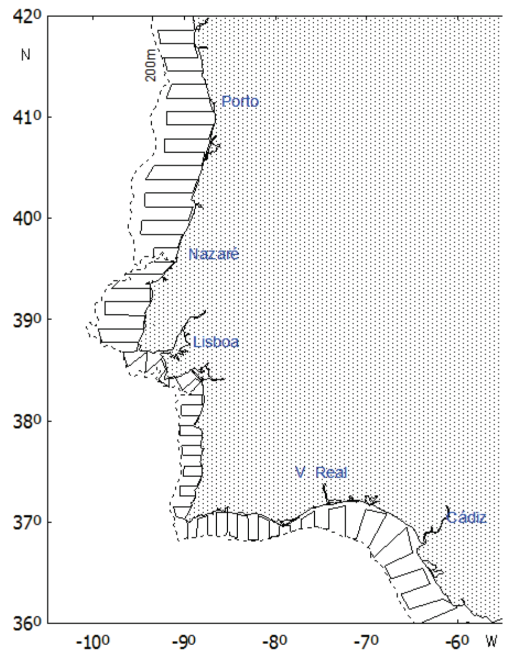

Figure B.3.2.1.1. Acoustic transects sampled during the PELAGOS acoustic survey in 2011.

For each species, the acoustic energy is also partitioned by length classes according to the length structure found in the trawl hauls. The biomass is derived from the number of individuals, applying the weight–length relationship obtained from the haul samples.

B.3.2.1.2. Spanish spring acoustic survey: PELACUS

The spring acoustic survey PELACUS (on board the RV "Thalassa") covers the area between northern Portuguese waters and southern French waters. Acoustic sampling takes place during the day, over a grid of parallel transects separated by 8 nm and perpendicular to the coastline. The area covered by the survey extends from 30 to 200 m depth. The EDSU is fixed at 1 nm. Fish abundance estimation is only carried out with the 38 kHz frequency of a Simrad EK60 scientific echosounder, although echograms from 120 kHz are also used to help discrimination. No threshold is set for integration.

Backscattering energy is allocated to fish species by visual scrutiny of the echograms and based on the information provided by the fishing trawls. Fishing stations are analysed and grouped according to depth and proximity criteria and their representativeness is assessed based on the continuity in the probability density function of the length distribution for all fish species in the haul.

The main differences between surveys are related to the sampling strategy and the type of gear used. Noruega's main objective is estimating sardine and anchovy abundance while Thalassa samples all fish aggregations. Noruega's net is smaller than Thalassa's, which allows Noruega to carry out trawls closer to the shore while Thalassa can take advantage of a bigger pelagic trawl to sample schools in more offshore areas.

Figure B.3.2.1.2. Acoustic transects sampled during the PELACUS acoustic survey in 2011.

B.3.2.1.3 French spring acoustic survey: PELGAS

The French acoustic survey (PELGAS) is routinely carried out each year in spring in the Bay of Biscay (on board the RV Thalassa) and information on pelagic fish species distribution and abundance is available since 2000. The main species targeted is anchovy but the survey is part of the Ifremer programmes on data collection for monitoring and management of fisheries with an ecosystemic approach for fisheries and information is therefore also collected on other pelagic species, on egg presence and abundance, on top predators abundance and distribution and on environmental variables such as temperature, salinity, plankton, etc. The survey is planned with Spain and Portugal in order to have most of the potential area to be covered from Gibraltar to Brest with the same protocol for sampling strategy. Data are made available to the ICES working groups WGHANSA, WGWIDE and WGACEGG.

Acoustic data are collected along systematic parallel transects perpendicular to the French coast. The length of the ESDU (Elementary Sampling Distance Unit) was one mile and the transects were uniformly spaced by 12 nautical miles covering the continental shelf from 20 m depth to the shelf break. Acoustic data are collected only during the day because of pelagic fish behaviour in the area. These species are usually dispersed very close to the surface during the night and so "disappear" in the blind layer for the echosounder between the surface and 8 m depth.

Since 2008, PELGAS survey has been accompanied by pelagic pairtrawlers that follow the RV Thalassa transects. Identification hauls were carried out both by the RV Thalassa and the commercial vessels being preferentially carried out by pairtrawlers which are more efficient (less avoidance to the vessels) and hauls close to the bottom being preferentially carried out by the RV Thalassa.

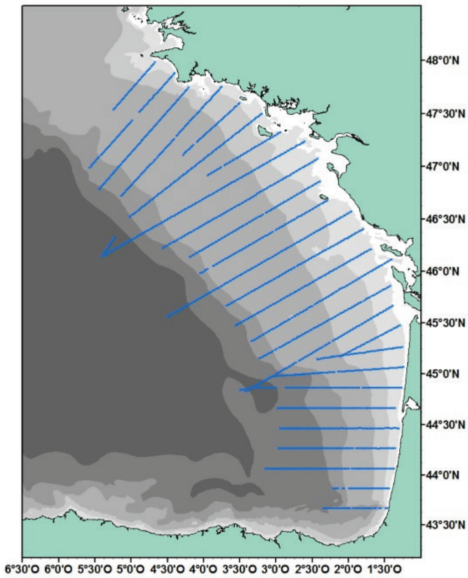

Figure B.3.2.1.3. Acoustic transects sampled during the PELGAS acoustic survey in 2011.

B.4. Commercial cpue

Cpue indices are not considered reliable indicators of abundance for small pelagic fish (Ulltang, 1982; Csirke, 1988; Mackinson *et al.*, 1997) and are not used.

B.5. Other relevant data

C. Assessment: data and method

Model used: Stock Synthesis (SS, Methot, 1990, 2005). SS is a generalized age- and length-based model that is very flexible with regard to the types of data that may be included, the functional forms that are used for various biological processes, the level of complexity and number of parameters that may be estimated. A description and discussion of the model can be found in ICES (2010).

The sardine assessment is an age-based assessment assuming a single area, a single fishery, a yearly season and genders combined. Input data include catch (in biomass), age composition of the catch, total abundance (in numbers) and age composition from an annual acoustic survey and spawning–stock biomass (SSB) from a triennial DEPM survey. Considering the current assessment calendar (annual assessment WG in June in year *y+1*), the assessment includes fishery data up to year *y* and acoustic data up to year *y+1*. According to the ICES terminology, year *y* is the final year of the assessment and year *y+1* is termed the interim year.

Software used:

Stock Synthesis (SS) version 3.21d (Methot, 2011)

Model Options chosen:

The main model options are described below. A copy of the control file (sardine.ctl) including all model options is appended to the bottom of this section.

Natural mortality are age specific input values as listed in the table below.

Age 0	0.8
Age 1	0.5
Age 2	0.4
Age 3	0.3
Age 4	0.3
Age 5	0.3
Age 6+	0.3

Growth is not modelled explicitly. Weights-at-age in the beginning and mid of the year are input values and fecundity-at-age are input values, corresponding to the proportion mature-at-age * weight-at-age at the beginning of the year.

Annual recruitments are parameters, defined as lognormal deviations from a constant mean value penalized by a sigma of 0.55 (the standard deviation of log(recruits) estimated in the 2011 assessment, ICES, 2011a). Recruitment for the interim year of the assessment is assumed to be the historic geometric mean.

Fishing mortality is applied as the hybrid method. This method does a Pope's approximation to provide initial values for iterative adjustment of the continuous F values to closely approximate the observed catch.

Total catch biomass by year is assumed to be accurate and precise. The F values are tuned to match this catch.

Total catch biomass by year is assumed to be a median unbiased index of abundance.

Both the acoustic survey and the DEPM survey are assumed to be relative indices of abundance. The corresponding catchability coefficients are considered to be mean unbiased.

Age selectivity in the fishery and in the acoustic survey is such that the parameter for each age is estimated as a random walk from the previous age (however, this applies only to ages 1, 2, 3 and 6+ in the fishery and 2 and 6+ in the survey). In the fishery, selectivity-at-age 0 is not estimated and is used as the reference age against which subsequent changes occur. A similar assumption is considered for age 1 in the survey, the first observed age. Selectivities at ages 3 to 5 years in the fishery are bound, meaning that parameters for ages 4 and 5 are not estimated but assumed to be equal to the parameter estimated for age 3. A similar assumption is accepted for ages 2 to 5 years in the survey. The initial values for the fishery and survey selectivities mimic dome-shaped patterns with a decline at the 6+ group. However, the range of initial values is wide and almost any pattern can be estimated.

The fishery selectivity is allowed to vary over time in part of the assessment period. Two periods are considered: 1978–1990 with selectivity-at-age varying as a random walk and 1991–2010 for which selectivity-at-age is fixed over time. In the random walk, log(Sy) = log(Sy-1 + delta(y)), with SD=0.1 as the penalty on the deltas, y being the year). The transition between periods is done as a random walk as well.

In the interim year of the assessment, there is data from the acoustic survey but not from the fishery (catch and age composition). The model requires input fishery data for all assessment years. Catch biomass for the interim year is assumed to be equal to the ICES advised catch (75 000 tons in 2011). Age composition data for the fishery in the interim year is included in the calculation of expected values but excluded from the objective function. Catch numbers-at-age in the interim year are derived from numbers-at-age in the previous year assuming the same fishing mortality, selectivity pattern and biological parameters. An arbitrary value of 4 000 000 individuals was assumed as the interim recruitment.

The objective function is a log likelihood combining components for:

Catch biomass (lognormal);

acoustic survey abundance index (lognormal);

DEPM survey SSB (lognormal);

fishery age composition (multinomial);

survey age composition (multinomial);

recruitment deviations (lognormal);

random walk selectivity parameters (normal);

initial equilibrium catch (normal).

Estimates of data precision are included in the likelihood components for the abundance indices and age composition data as follows:

a standard error of 0.25 is assumed for all years both for the acoustic index (total number of fish) and the DEPM index (SSB). In the likelihood components of each survey, annual log residuals are divided by the corresponding standard errors. Therefore, the two surveys and the years within each survey have equivalent weight in the objective function. The assumed standard error corresponds to a CV of 25% which is consistent with the average level of CVs estimated for the acoustic survey by geostatistics (range 12–43%, mean=23%) and GAM methods (Zwolinski *et al.*, 2009) and with CVs estimated for the DEPM survey (range 14–32%, mean =22%).

assumed sample sizes for annual age compositions in the fishery and acoustic survey are:

Fishery		Acoustic survey	
1978-1990	50	1996-2011	50
1991-2010	75		

Sample size sets the precision of the age composition data. It should correspond to the actual number of fish in the age samples if the multinomial error model was strictly correct (i.e. the number of independent observations in a sample). In general, the levels of age sampling for the sardine stock are high in both the fishery and the acoustic survey (see Table B.1.2). Although input values for sample size can be calculated from the sampling data, it is difficult to obtain real values since there is often autocorrelation within age samples. Therefore, sample sizes were calculated approximately taking into account the harmonic mean of expected sample sizes provided by the model. The sample size for fishery age compositions was assumed to be lower in the period 1978–1990 than afterwards to reflect the poorer regional coverage of stock landings (ICES, 2012; WKPELA Report);

indices of ageing imprecision were obtained from the most recent age reading workshop (ICES, 2011b). Three sets of otoliths from different stock regions were aged by readers implicated in the preparation of ALKs. Standard deviations by age and reader were calculated relative to the modal age for each regional otolith set. These SDs were averaged over all readers and a weighted average for the three sets was calculated assuming the weights in the table below. Ageing imprecision was assumed to be constant over time and to be the same in the fishery and in the survey. Within the model, a transition matrix defines the expected distribution of observed ages for each true age assuming a normal distribution with mean equal to the true age and standard deviations as given in the table below.

Age	Portuguese coast	Cantabrian Sea	Gulf of Cadiz	Weighted Average
0	0.13	0.08	0.26	0.1
1	0.17	0.19	0.16	0.2
2	0.30	0.24	0.24	0.3
3	0.23	0.26	0.30	0.2
4	0.24	0.26	0.45	0.3
5	0.27	0.19	0.45	0.3
6	0.40	0.40	0.53	0.4
7	0.25	0.33	0.48	0.3
Weights	0.60	0.30	0.10	

The initial equilibrium catch was set at 100 000 tons, the recent level of catches. The model uses the initial equilibrium catch to derive an initial fishing mortality. The population numbers-at-age in the initial year (the year before the first year of the assessment period) are calculated from the mean recruitment, the initial equilibrium catch and the selectivity in the first year. Numbers-at-age in the first year of the assessment are derived from those in the initial year assuming the mean recruitment.

Minimization of the likelihood is implemented in phases using standard ADMB process. The phases in which estimation will begin for each parameter is shown in the control file appended to this section.

Variance estimates for all estimated parameters are calculated from the Hessian matrix.

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1978 forward	Ages 0–6+	
Canum	Catch-at-age in numbers	1978 forward	Ages 0–6+	
Weca	Weight-at-age in the commercial catch	1978 forward	Ages 0–6+	1978–1991 No 1992 forward Yes
West	Weight-at-age of the spawning stock at spawning time.	1978 forward	Ages 0–6+	1978–1990 No 1991 forward Yes
Matprop	Proportion mature-at-age	1978 forward	Ages 0–6+	Estimated in DEPM years, else assumed constant
Natmor	Natural mortality	1978 forward	Ages 0–6+	No

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	Joint SP+PT Acoustics	1996 onwards	Ages 1–6+
Tuning fleet 2	Joint SP+PT DEPM	1997, 1999, 2002, 2005, triennal	Not age structured

The model estimates spawning–stock biomass (SSB) and summary biomass (B1+, biomass of age 1 and older) at the beginning of the year. The reference age range for output fishing mortality is 2–5 years.

```
#C Sardine in VIIIc and IXa : Benchmark assessment

#C growth parameters are estimated spawner-recruitment bias adjustment Not tuned For optimality

#_data_and_control_files: sardine.dat // sardine.ctl

1 #_N_Growth_Patterns

1 #_N_Morphs_Within_GrowthPattern

1 #_Nblock_Patterns

1 #_blocks_per_pattern

# begin and end years of blocks

 1978 1990

#

0.5 #_fracfemale

3 #_natM_type:_0=1Parm; 1=N_breakpoints;_2=Lorenzen;_3=agespecific;_4=agespec_withseasinterpolate

0.8 0.5 0.4 0.3 0.3 0.3 0.3 #_no additional input for selected M option; read 1P per morph

1 # GrowthModel: 1=vonBert with L1&L2; 2=Richards with L1&L2; 3=age_speciific_K; 4=not implemented

0 #_Growth_Age_for_L1
```

6 #_Growth_Age_for_L2 (999 to use as Linf)

0 #_SD_add_to_LAA (set to 0.1 for SS2 V1.x compatibility)

0 #_CV_Growth_Pattern: 0 CV=f(LAA); 1 CV=F(A); 2 SD=F(LAA); 3 SD=F(A); 4 logSD=F(A)

5 #_maturity_option: 1=length logistic; 2=age logistic; 3=read age-maturity matrix by growth_pattern; 4=read age-fecundity; 5=read fec and wt from wtatage.ss

#_placeholder for empirical age-maturity by growth pattern

1 #_First_Mature_Age

1 #_fecundity option:(1)eggs=Wt*(a+b*Wt);(2)eggs=a*L^b;(3)eggs=a*Wt^b; (4)eggs=a+b*L; (5)eggs=a+b*W

0 #_hermaphroditism option: 0=none; 1=age-specific fxn

1 #_parameter_offset_approach (1=none, 2= M, G, CV_G as offset from female-GP1, 3=like SS2 V1.x)

2 #_env/block/dev_adjust_method (1=standard; 2=logistic transform keeps in base parm bounds; 3=standard w/ no bound check)

#

#_growth_parms

#_LO	HI	INIT	PRIOR	PR_type	SD	PHASE	env-var	use_dev	dev_minyr	dev_maxyr	dev_stddev	Block	Block_Fxn		
8	18	14	0	-1	0	-2	0	0	0	0	0	0	0	#	L_at_Amin_Fem_GP_1
20	25	23	0	-1	0	-4	0	0	0	0	0	0	0	#	L_at_Amax_Fem_GP_1
0.2	0.8	0.4	0	-1	0	-4	0	0	0	0	0	0	0	#	VonBert_K_Fem_GP_1
0.05	0.25	0.1	0	-1	0	-3	0	0	0	0	0	0	0	#	CV_young_Fem_GP_1
0.05	0.25	0.1	0	-1	0	-3	0	0	0	0	0	0	0	#	CV_old_Fem_GP_1
-3	3	2	0	-1	0	-3	0	0	0	0	0	0	0	#	Wtlen_1_Fem
-3	4	3	0	-1	0	-3	0	0	0	0	0	0	0	#	Wtlen_2_Fem
50	60	55	0	-1	0	-3	0	0	0	0	0	0	0	#	Mat50%_Fem
-3	3	-0.25	0	-1	0	-3	0	0	0	0	0	0	0	#	Mat_slope_Fem
-3	3	1	0	-1	0	-3	0	0	0	0	0	0	0	#	Eggs/kg_inter_Fem
-3	3	0	0	-1	0	-3	0	0	0	0	0	0	0	#	Eggs/kg_slope_wt_Fem

0	0	0	0	-1	0	-4	0	0	0	0
	0	0	0	#	RecrDist_GP_1					
0	0	0	0	-1	0	-4	0	0	0	0
	0	0	0	#	RecrDist_Area_1					
0	0	0	0	-1	0	-4	0	0	0	0
	0	0	0	#	RecrDist_Seas_1					
0	0	0	0	-1	0	-4	0	0	0	0
	0	0	0	#	CohortGrowDev					

#_Spawner-Recruitment

4 #_SR_function: 2=Ricker; 3=std_B-H; 4=SCAA; 5=Hockey; 6=B-H_flattop; 7=survival_3Parm

#_LO	HI	INIT	PRIOR	PR_type	SD	PHASE		
1	12	8.9	4.5	-1	5	1	#	SR_LN(R0)
0.2	1	0.9	0.7	-1	0.05	-5	#	SR_SCAA_null
0	4	0.55	0.6	-1	0.8	-4	#	SR_sigmaR
-5	5	0.1	0	-1	1	-3	#	SR_envlink
-5	5	0	0	-1	1	-4	#	SR_R1_offset
0	0	0	0	-1	0	-99	#	SR_autocorr

0 #_SR_env_link

0 #_SR_env_target_0=none;1=devs;_2=R0;_3=steepness

1 #do_recdev: 0=none; 1=devvector; 2=simple deviations

1978 # first year of main recr_devs; early devs can preceed this era

2010 # last year of main recr_devs; forecast devs start in following year

2 #_recdev phase

1 # (0/1) to read 13 advanced options

0 #_recdev_early_start (0=none; neg value makes relative to recdev_start)

-4 #_recdev_early_phase

-1 #_forecast_recruitment phase (incl. late recr) (0 value resets to maxphase+1)

1 #_lambda for Fcast_recr_like occurring before endyr+1

1900 #_last_early_yr_nobias_adj_in_MPD

1900 #_first_yr_fullbias_adj_in_MPD

1900 #_last_yr_fullbias_adj_in_MPD

1900 #_first_recent_yr_nobias_adj_in_MPD

1 #_max_bias_adj_in_MPD (-1 to override ramp and set biasadj=1.0 for all estimated recdevs)

0 #_period of cycles in recruitment (N parms read below)

-5 #min rec_dev

5 #max rec_dev

0 #_read_recdevs

#_end of advanced SR options

#Fishing Mortality info

0.3 # F ballpark for tuning early phases

-2001 # F ballpark year (neg value to disable)

3 # F_Method: 1=Pope; 2=instan. F; 3=hybrid (hybrid is recommended)

2 # max F or harvest rate, depends on F_Method

4 # N iterations for tuning F in hybrid method (recommend 3 to 7)

#

#_initial_F_parms

#_LO HI INIT PRIOR PR_type SD PHASE

0 2 0.3 0.3 -1 0.2 1 # InitF_1purse_seine

#

#_Q_setup

Q_type options: <0=mirror, 0=median_float, 1=mean_float, 2=parameter, 3=parm_w_random_dev, 4=parm_w_randwalk, 5=mean_unbiased_float_assign_to_parm

#_for_env-var:_enter_index_of_the_env-var_to_be_linked

#_Den-dep env-var extra_se Q_type

0 0 0 0 # 1 purse_seine

0 0 0 1 # 2 Acoustic_survey

0 0 0 2 # 3 DEPM_survey

#

#_Cond 0 #_If q has random component, then 0=read one parm for each fleet with random q; 1=read a parm for each year of index

#_Q_parms(if_any)

LO HI INIT PRIOR PR_type SD PHASE

-7 5 0 0 -1 1 1 # Q_base_3_DEPM_survey

#_age_selex_types

#_Pattern ___ Male Special

17 0 0 0 # 1 purse_seine

17 0 0 0 # 2 Acoustic_survey

10 0 0 0 # 3 DEPM_survey

#_LO	HI	INIT	PRIOR	PR_type	SD	PHASE	env-var	use_dev	dev_minyr	dev_maxyr	dev_stddev	Block	Block_Fxn	
-5	5	0	0	-1	0.01	-2	0	0	0	0	0.1	0	0	# AgeSel_1P_1_purse_seine
-5	5	0.9	0.5	-1	0.01	2	0	3	1978	1990	0.1	1	3	# AgeSel_1P_2_purse_seine
-5	5	0.4	0.5	-1	0.01	2	0	3	1978	1990	0.1	1	3	# AgeSel_1P_3_purse_seine
-5	5	0.1	0.3	-1	0.01	2	0	3	1978	1990	0.1	1	3	# AgeSel_1P_4_purse_seine
-5	5	0	0.1	-1	0.01	-2	0	0	0	0	0.1	0	0	# AgeSel_1P_5_purse_seine
-5	5	0	0.1	-1	0.01	-2	0	0	0	0	0.1	0	0	# AgeSel_1P_6_purse_seine
-5	5	-0.5	0.5	-1	0.01	2	0	3	1978	1990	0.1	1	3	# AgeSel_1P_7_purse_seine
-1000	-1000	-1000	-6	-1	0.01	-2	0	0	0	0	0	0	0	# AgeSel_2P_1_Acoustic_survey
-5	5	0	0.5	-1	0.01	-2	0	0	0	0	0	0	0#	AgeSel_2P_2_Acoustic_survey
-5	9	-0.3	0	-1	0.01	2	0	0	0	0	0	0	0#	AgeSel_2P_3_Acoustic_survey
-5	9	0	0	-1	0.01	-2	0	0	0	0	0	0	0#	AgeSel_2P_4_Acoustic_survey
-5	9	0	0	-1	0.01	-2	0	0	0	0	0	0	0#	AgeSel_2P_5_Acoustic_survey
-5	9	0	0	-1	0.01	-2	0	0	0	0	0	0	0#	AgeSel_2P_6_Acoustic_survey
-5	9	-0.8	-1	-1	0.01	2	0	0	0	0	0	0	0#	AgeSel_2P_7_Acoustic_survey

1 #_custom_sel-blk_setup (0/1)

-5 5 0.9 1 -1 0.01 2 # AgeSel_1P_2_purse_seine_BLK1delta_1978

-5 5 0.4 1 -1 0.01 2 # AgeSel_1P_3_purse_seine_BLK1delta_1978

-5 5 0.1 1 -1 0.01 2 # AgeSel_1P_4_purse_seine_BLK1delta_1978

-5 5 -0.5 1 -1 0.01 2 # AgeSel_1P_7_purse_seine_BLK1delta_1978

4 #_selparmdev-phase

1 #_env/block/dev_adjust_method (1=standard; 2=logistic trans to keep in base parm bounds; 3=standard w/ no bound check)

1 #_Variance_adjustments_to_input_values

#_fleet: 1 2 3

0 0 0 #_add_to_survey_CV

0 0 0 #_add_to_discard_stddev

0 0 0 #_add_to_bodywt_CV

0 0 0 #_mult_by_lencomp_N

1 1 1 #_mult_by_agecomp_N

1 1 1 #_mult_by_size-at-age_N

4 #_maxlambdaphase

1 #_sd_offset

3 # number of changes to make to default Lambdas (default value is 1.0)

Like_comp codes: 1=surv; 2=disc; 3=mnwt; 4=length; 5=age; 6=SizeFreq; 7=sizeage; 8=catch;

9=init_equ_catch; 10=recrdev; 11=parm_prior; 12=parm_dev; 13=CrashPen; 14=Morphcomp; 15=Tag-comp; 16=Tag-negbin

like_comp fleet/survey phase value sizefreq_method

9 1 1 1 1

4 2 2 1 1

4 2 3 1 1

D. Short-term projection

Model and software used: Multi Fleet Deterministic Projection (MFDP)

The initial stock size corresponds to the assessment estimates for ages 1–6+ at the final year. Recruitment (Age 0) estimated in the final year of the assessment is accepted for the projection since it is supported by data from the acoustic survey in the interim year. Recruitment in the interim year and forecast year will be set equal to a pre-agreed level of recruitment according to the update assessment. This level corresponds to the geometric mean recruitment of the last 15 years. The period selected does not cover the entire assessment period because there is a decreasing trend in recruitment throughout the historical period. A 15 year period will integrate some bad and good recruitments without being too much dependent to the most recent recruits estimated by the model.

The maturity ogive corresponds to the ogive used in the assessment (in years with no DEPM survey), i.e. 0% mature at age 0, 80% mature at age 1 and 100% mature at age 2+.

Input values for the proportion of F and M before spawning are zero, which correspond to the beginning of the year when the SSB is estimated by the model.

Weights-at-age in the stock and in the catch are calculated as the arithmetic mean value of the last three years of the assessment.

Natural mortality-at-age is equal to that used in the assessment.

The exploitation pattern is the average of the last three years of the assessment.

Predictions are carried out with an $F_{multiplier}$ (usually ranging from 0 to 2) assuming an F_{sq} equal to the average estimates of the last three years in the assessment. In the interim year, catches are constrained to be an agreed expected level (since data in not yet available), usually those corresponding to F_{sq} (0.36) or alternatively as duly justified by stock assessment scientists. Predicted population at the beginning and end of the forecast year will be shown according to preselected levels of fishing mortality in consonance with defined precautionary and target reference points.

E. Medium-term projections

Not carried out.

F. Long-term projections

Not carried out.

G. Biological reference points

	Type	Value	Technical basis
MSY	MSY $B_{trigger}$	xxx t	Undefined
Approach	F_{MSY}	0.35	$F_{BPR50\%}$, F at which the B1+/R is half of what it would have been in the absence of fishing
	B_{lim}	307 000 t	B_{lim}=B_{loss} (2000 B1+), B_{loss} being the lowest historical biomass which produced good recruitments
Precautionary	B_{pa}	xxx t	Undefined
Approach	F_{lim}	Xxx	Undefined
	F_{pa}	Xxx	Undefined

Reference points are expressed in terms of B_{1+}, the biomass of age 1 and older individuals. B_{1+} corresponds to total-stock biomass at the beginning of the year.

H. Other issues

H.1. Historical overview of previous assessment methods

From 2003 to the current benchmark, the sardine stock was assessed using the age structured model AMCI (Assessment Model Combining Information from various sources, Skagen, 2005). Because the program is not going to be maintained in the future, alternative programs have been explored. Stock Synthesis (SS3) has been chosen as the final assessment model in the 2012 benchmark since it offers the same level of flexibility of AMCI and additional features, such as the possibility to incorporate uncertainty of input data in the variance of final estimates. Other SS3 abilities which were not explored due to time limitation but might be useful in the future are: link to environmental data (e.g. to recruitment), include several fleets and areas (explain spatial differences in sardine demography) and use of the forecast module.

Summary of data ranges used in recent assessments:

Data	2006 assessment	2007 assessment	2008 assessment	2009 assessment
Catch data	Years: 1978–(AY-1) Ages: 1–8+	Years: 1978–(AY-1) Ages: 1–8+	Years: 1978–(AY-1) Ages: 1–8+	Years: 1978–(AY-1) Ages: 1–8+
Survey: A_Q1	Years: 1985–AY Ages: 1–7	Years: 1985–AY Ages 1–7	Years: 1985– AY Ages 1–7	Years: 1985–AY Ages 1–7
Survey: B_Q4	Years: 1996–(AY-1) Ages: 1–5	Years: 1996– AY-1) Ages 1–7	Years: 1996– AY-1) Ages 1–7	Years: 1996–AY-1) Ages 1–7
Survey: C	Not used	Not used	Not used	Not used

AY – Assessment year

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A.5.4 Stock Annex: Southern Horse Mackerel

Stock	Horse Mackerel in Division IXa (Southern horse mackerel)
Working Group:	WGANSA
Date:	30 January 2011
Revised by	Alberto Murta, Pablo Abaunza, Jim Ianelli (WKBENCH, 2011)

A. General

A.1. Stock definition

Stock units

For many years the Working Group has considered the horse mackerel in the northeast Atlantic as separated into three stocks: the North Sea, the Southern and the Western stocks (ICES, 1990; ICES 1991). Until the results from the EU project (HOMSIR, QLK5-Ct1999-01438), were available, the separation into stocks was based on the observed egg distributions and the temporal and spatial distribution of the fishery. The extremely strong 1982 year class appeared for the first time in the eastern part of the North Sea in 1987, during the third and mainly the fourth quarter. This year class was the basis for the start of the Norwegian horse mackerel fishery in the eastern part of North Sea during the third and mainly the fourth quarter. Since Western horse mackerel are assumed to have broadly similar migration patterns as NEA mackerel the Norwegian catches have been considered to be fish of western origin migrating to this area to feed. In addition, there is a fishery further south in the North Sea which is considered to be fish of North Sea origin. These views were supported by results from the mentioned EU project which was reviewed in ICES (2004) which also concluded to include Division VIIIc as part of the distribution area of the western horse mackerel stock (see also Abaunza *et al*., 2008 for a comprehensive discussion of the results from the HOMSIR project). Horse mackerel off the west coast of the Iberian Peninsula have characteristics (morphometry, parasites, distribution and migratory circuit) that distinguish them from the rest of the samples collected in the northeast Atlantic. The border between southern and western horse mackerel stocks may therefore lie at the level of Cape Finisterre on the coasts of Galicia at 43°N, which is also the limit between Division VIIIc and IXa. The southern limit of the southern horse mackerel stock is not as evident due to the lack of samples from the north of Africa. Based on morphometric studies, Murta (2000) showed that the horse mackerel of the Portuguese coast was closer to the northwest coast of Morocco than to the Gulf of Cadiz in the south of Spain. However, the respective parasite composition suggests that the populations off the north of Africa and the west of the Iberian Peninsula are not part of a continuous stock.

Data from bottom-trawl surveys carried out throughout the Atlantic waters of the Iberian Peninsula during the autumn supported the existence of ontogenic migrations (Murta *et al*., 2008). Analysis of the proportion of each year class in each area off the Portuguese coast indicated that most year classes recruit to the northwest area (close to Area 8) and then move progressively southwards. After six years of age, they return to the north.

Allocation of catches to stocks

Based on spatial and temporal distribution of the horse mackerel fishery, the catches were allocated to the three stocks as follows:

Western stock: Divisions IIa, IIIa (western part), Vb, IVa (third and fourth quarter), VIa, VIIa–c,e–k and VIIIa–e. Although it seems strange that only catches from western part of Division IIIa are allocated to this stock, the catches in the western part of this Division taken in the fourth quarter often are taken in neighbouring area of catches of western fish in Division IVa. The Working Group is not sure if catches in Divisions IIIa and IVa during the first two quarters are of western or North Sea origin. Usually this is a minor problem because the catches here during this period are small. However, in 2006 relatively larger catches were taken in this area during the first half of the year (3600 tons) and these catches were allocated to the North Sea stock. In 2007, 2100 tons were caught during the two first quarters in Divisions IVa and IIIa and were allocated to the North Sea stock.

North Sea stock: Divisions IIIa (eastern part), IVa (first and second quarter), IVb,c and VIId. The catches in 3–4 quarters of Divisions IVa and IIIa and 1–4 quarters from Divisions IVb,c and VIId were allocated to the North Sea stock. In 2007, some small catches were reported from Divisions IIIb (4 tons) and IIIc (21.5 tons) and were allocated to the North Sea stock.

Southern stock: Division IXa. All catches from these areas are allocated to the southern stock.

A.2. Fishery

The catches of horse mackerel in Division IXa (Subdivision IXa North, Subdivision IXa Central-North, Subdivision IXa Central-South and Subdivision IXa South) are allocated to the Southern horse mackerel stock. In the years before 2004 the catches from Subdivisions VIIIc West and VIIIc East, were also considered to belong to the southern horse mackerel stock.

The Spanish catches in Subdivision IXa South (Gulf of Cádiz) are available since 2002. They will not be included in the assessment data until they are available for all assessment years, to avoid a possible bias in the assessment results. On the other hand, the total catches from the Gulf of Cádiz are scarce and represent less than the 5% of the total catch. Therefore, their exclusion should not affect the reliability of the assessment.

The “Prestige” oil spill had also an effect on the fishery activities in the Spanish area (Division IXa North) in 2003. The Spanish catches increased markedly from 1991 until 1998, whereas the Portuguese catches were more stable, showing a smooth decreasing trend since the peak observed in 1992 (with a secondary peak in 1998).

Catches in Subdivisions IXa Central-North showed a decreasing trend whereas in Subdivision IXa North they increased markedly until 1998, and since then, the catches always have been higher than 7000 t. The catches from bottom trawlers are the majority in both countries. The rest of the catches are taken by purse seiners, especially in the Spanish area and by the artisanal fleet which is much more important in the Portuguese area.

Description of the Portuguese fishing fleets operating in Division IXa (data provided by the Portuguese Fisheries Directorate) and catch horse mackerel (only trawlers and purse seiners):

Gear	Length	Storage	Number of boats
Trawl	10-20	Freezer	2
Trawl	20-30	Freezer	7
Trawl	30-40	Freezer	5
Trawl	0-10	Other	259
Trawl	10-20	Other	68
Trawl	20-30	Other	60
Trawl	30-40	Other	29
Purse seine	0-10	Other	79
Purse seine	10-20	Other	103
Purse seine	20-30	Other	79

Note that horse mackerel is also caught in all polyvalent and most small scale fisheries.

Description of the Spanish fishing fleets operating in Division IXa including the Gulf of Cádiz (Southern stock) and Division VIIIc (Western stock) (Hernández, 2008):

Gear	Bottom trawl	Purse seine	Lgline Bottom	Lgline surface	Gillnet (big mesh size)	Gillnet	Other artisanal
Number	282	410	100	67	35	57	5379
Construction year (mean)	1996	1992	1990	1995	1990	1993	1982
Length	9–35 (22.9)	8–38 (21)	6–28 (15.1)	18–38 (27.6)	4–28.6 (14)	12–27 (17.2)	3–27 (7)
Power	66–800 (322.3)	24–1100 (302.5)	12–476 (150.3)	175–780 (418.9)	10–500 (141.8)	50–408 (164.9)	2–450 (32.6)
Tonnage	6–228 (81.2)	4–221 (56.6)	2–118 (26)	37–206 (116)	1–110 (23.7)	10–99 (27.6)	0.3–83 (3.5)

It is indicated the range and the arithmetic mean (in parenthesis). Data from official census (Hernández, 2008). Note that horse mackerel in the Spanish area is mainly fished by bottom trawlers and purse seiners.

The Spanish bottom-trawl fleet operating in ICES Divisions VIIIc (Western stock) and Subdivision IXa north (Southern stock), historically relatively homogeneous, has evolved in the last decade (approximately since 1995) to incorporate several new fishing strategies. A classification analysis for this fleet between the years 2002 and 2004 was made based on the species composition of the individual trips (Castro and Punzón, 2005). The analysis resulted in the identification of five catch profiles in the bottom otter trawl fleet: 1) targeting horse mackerel (>70% in landings), 2) targeting mackerel (>73% in landings); 3) targeting blue whiting (>40% in landings); 4) targeting demersal species; and 5) a mixed "métier". In the bottom pair trawl fleet the classification analysis showed two métiers: 1) targeting blue whiting; and 2) targeting hake. These results should help in obtaining standardized and more coherent cpue series from fishing fleets.

In the Portuguese area (Division IXa) Silva and Murta (2007) classified trawl fleet in two main types: those targeting fish and cephalopods species and those fishing crustaceans. Looking at the fishing trips of those that catch fish and cephalopods, they identified three main clusters: 1) targeting horse mackerel, 2) targeting cephalopods, and 3) a poorly defined mixed cluster.

In 2005, the landings of blue whiting increased, probably due to increased market demand and consequent reduction of discards, resulting in a fourth specific cluster. The Crustacean trawl clusters do not follow the same pattern every year, depending on the abundance of the two main target crustacean species, which are Norway lobster and deep-water rose shrimp. There can be one target species by cluster or mixed clusters with different percentages of these two species.

A.3. Ecosystem aspects

Influence of environmental drivers on the stock dynamic

The southern horse mackerel stock is distributed along the western and southern Atlantic coasts of the Iberian Peninsula, which is an area subject to upwelling events. There is already evidence in the literature that horse mackerel recruitment is influenced by environmental drivers. The analysis carried out under the IN EX Fish project (Frid *et al*., 2009) showed that non-linear combinations of NAO and upwelling indices were able to explain the strength of past recruitments. The rise and fall of this horse mackerel stock was probably caused by a complex interaction of different factors, both human and natural. However, it is very likely that changes in recruitment due to upwelling and NAO events may have played an important role.

Role of multispecies interactions

Horse mackerel is a schooling species and often close to the sea floor. Shelf attachment is a predominant distributional pattern for this stock. Therefore, horse mackerel is in relation with other fish and invertebrate species that are usually caught during the bottom-trawl surveys and share the same habitat. These species are mainly: snipefish, boarfish, blue whiting, European hake, sardine, blue jack mackerel, squid and pelagic crabs (Sousa *et al*., 2006).

Trophic interactions

Young horse mackerel is a feeding resource consumed by several demersal, benthic and pelagic predators present in the distribution area like: hake, monkfish, John Dory, bluefin tuna and dolphins.

Horse mackerel is mainly a zooplanktivorous species. Diet variations with fish length and water depth are correlated: small fish are closely associated with coastal areas where they feed on copepods and decapod larvae (Cabral and Murta, 2002). However, they can prey on fish as they grow. They become *Ichthyophagous* when they reach large sizes.

B. Data

B.1. Commercial catch

Mean length-at-age and mean weight-at-age

Both mean length-at-age and mean weight-at-age values are calculated by applying the mean, weighted by the catch, over the mean weights or mean lengths-at-age obtained by Subdivision.

Taking in consideration that the spawning season is very long, from September to June, and that the whole length range of the species has commercial interest in the

Iberian Peninsula, with probably very scarce discards, there is no special reason to consider that the mean weight in the catch is significantly different from the mean weight in the stock.

Catch in numbers-at-age

The sampling scheme is believed to achieve a good coverage of the fishery (above 95% of the total catch). The number of fish aged seems also to be sufficient through the historical series. Catch in numbers-at-age have been obtained by applying a quarterly ALK to each of the catch length distribution estimated from the samples of each subdivision. In the case of Subdivision IXa north, the catch in number estimates before 2003 have changed. In previous years the age–length key applied to the length distributions from Subdivision IXa north had included otoliths from Division VIIIc, which has been defined recently as part of the western stock. Since 2003, the catch in numbers-at-age from Subdivision IXa north were estimated using age–length keys which included only otoliths from Division IXa.

B.2. Biological

Maturity-at-age

For multiple spawners, such as horse mackerel, macroscopical analysis of the gonads cannot provide a correct and precise means to follow the development of both ovaries and testes. Histological analysis has to be included because it provides precise information on oocyte developmental stages and it can distinguish between immature gonads and regressing ones, or those partly spawned (Abaunza *et al.*, 2008). The HOMSIR project provided microscopical maturity ogives from the different IXa subdivisions. The maturity ogive from Subdivision IXa South is adopted here as the maturity-at-age for all years until 2006 of the southern stock, since it was based on a better sampling than in the others subdivisions. The percentage of mature female individuals per age group was adjusted to a logistic model.

In 2007 a new estimate of maturity proportion by age was available for Division IXa for the application of the Daily Egg Production Method (DEPM). This maturity ogive was then adopted since 2007 and will be revised with new data collected in the DEPM to be carried out in 2010.

Natural mortality

Natural mortality has been considered to be 0.15. This level of natural mortality was adopted for all horse mackerel stocks since 1992. However, the presence of very old horse mackerel specimens in the southern stock is much scarcer than in the western or North Sea stocks. On the other hand, the available references on natural mortality estimates for other *Trachurus* species (e.g. *Trachurus capensis, Trachurus japonicus* and *Trachurus murphyi*) show higher natural mortality values, being higher than 0.3 in the majority of cases (range from 0.1 to 0.5) (Cubillos *et al.*, 2008; MFMR, 2006; Zhang, 2001). Also, the assumption that natural mortality is the same for all ages is highly unrealistic, given that the chances of a 10 cm fish of being predated are much higher than those of a 30 cm fish.

As a conclusion, it is considered that the value of natural mortality (0.15) is an underestimation for southern horse mackerel stock. It is generally accepted that natural mortality is very high during larval stages and decreases as the age of the fish increases, approaching a steady rate (Jennings *et al.*, 2001). The natural mortality adopted in the assessment (mean = 0.3) is dependent on age, being higher for younger ages. The adopted values are the following and are based in the estimates for other similar pelagic species, observed diet composition of fish predators in the area and taking into account the observed mean life span in southern horse mackerel.

Age	0	1	2	3	4	5	6	7	8	9	10
Nat Mor	0.9	0.6	0.4	0.3	0.2	0.15	0.15	0.15	0.15	0.15	0.15

B.3. Surveys

The only survey datasets currently available for the assessment of southern horse mackerel are those from the bottom-trawl surveys carried out in the 4th quarter (October) by Portugal (Pt-GFS-WIBTS-Q4) and Spain (Sp-GFS-WIBTS-Q4) in ICES Division IXa. These surveys cover contiguous areas at the same time but do not cover the southern part of the stock distribution area, corresponding to the Spanish part of the Gulf of Cadiz. In that area another bottom-trawl survey is carried out Sp-GFS-caut-WIBTS-Q4), usually in November, but the raw data were unavailable in time for this workshop to investigate the effect of merging it with the datasets from the other areas. This work is expected to be completed in time for the next assessment working group, in June 2011.

As suggested in previous reviews of the assessment of this stock, the Spanish survey from Subdivision IXa North (Sp-GFS-WIBTS-Q4) and the Portuguese survey (Pt-GFS-WIBTS-Q4) are treated as a single survey, although they are carried out with different vessels and slightly different bottom-trawls. The catchability of these vessels (BO Cornide de Saavedra and NI Noruega) and fishing gears were compared for different fish species during project SESITS (EU Study Contract 96-029) and no significant differences were found for horse mackerel. Thus, the raw data (number per hour and age in each haul, including zeros) of the two datasets were merged and treated as a single dataset.

The abundance data by age and year do not follow a Normal distribution, having a big proportion of zeros and a few extreme values. This is explained by the patchiness in the distribution of horse mackerel and by its characteristic of forming large shoals. Therefore, it is questionable whether a simple average of the number-per-hour, by age and year, is an adequate abundance index for tuning the stock assessment. Different ways of obtaining an abundance index by age and year were explored, all of them based on the smoothing of the data assuming probability distributions other than the Normal one. For this, we fitted Generalized Additive Models (GAM) to the raw data using the package "mgcv" (Wood, 2006) in the R statistical computing language (R Core Development Team, 2010). Data smoothing was tried with four different strategies: by year class (one GAM for each year-class, with age as covariate), by age (one GAM by age with year as covariate), by year (one GAM by year with age as covariate), and by age and year (one GAM using a bi-dimensional smoother by age and year). A log link function was used in all cases, and the error was modelled with a binomial negative distribution. Other distributions and transformations of the data were tried, but with worse fittings than with these settings.

An example of the GAM fitting diagnostics with each of these four strategies showed in all cases a poor fitting, with the residuals showing undesirable patterns. Looking at the differences between the indices matrix obtained with each of these strategies and the one obtained by a simple average of the raw data, it is clear that most of the attempted strategies to smooth the data would result in strong differences, especially for the youngest ages. Given that an acceptable fit could not be achieved with these

GAMs, it was decided to use the simple averaged data as abundance indices for tuning the assessment. Further work must be carried out in the future to better address this problem.

Two very clear features can be observed in the abundance indices dataset: a strong variability of age 0 and strong year effects (some years with higher abundance of all ages than others). The first feature may be explained by the greater aggregation tendency of these small fish in dense shoals and by their typically pelagic behaviour, which makes them less available to the bottom trawl. When, by chance, one or a few of those shoals are captured by the bottom trawl (e.g. at the end of a haul when the trawl is being towed at mid-water), it contributes to a high abundance estimate of that age class. The apparent year effects in the data are more difficult to explain, and are likely due to natural variations in the availability of the fish in that time of the year and small variations in sampling effort (e.g. due to bad weather). Both the variability in age 0 and the apparent year effects must be accounted for in the assessment model to be fitted to these data.

Recent work suggests that horse mackerel has indeterminate fecundity (Gordo *et al.*, 2008), which makes the Annual Egg Production Method (AEPM) unsuitable to estimate SSB for this species. For species with indeterminate fecundity, the Daily Egg Production Method (DEPM) must be used instead. The existence of different series of data from egg surveys covering the whole area of the southern horse mackerel stock makes it possible to obtain egg production estimates using DEPM.

For this stock, a total of three SSB estimates, for the years 2002, 2005 and 2007, were made available. The SSB estimate and variance for 2007 was obtained from a DEPM egg survey directed at horse mackerel. Details of the sampling procedure, data obtained and methods followed are available from the 2008 report of the Working Group on Mackerel and Horse Mackerel Egg Surveys (ICES, 2008. ICES CM 2008/LRC:09). However, some details were corrected after the WGMEGS report, namely the total egg distribution area (which was corrected from 1.7e11 sq.meter to 7.1e11 sq.meter) and the fitting of the mortality curve to the egg abundance data, which was done using a GLM with a log link and assuming a Poisson distribution for the variance, instead of the non-linear regression described in the WGMEGS report. This resulted in a change of egg production from 13 eggs/sq.meter to 17 eggs/sq.meter.

The 2002 and 2005 estimates were obtained with egg abundance data collected during the surveys directed at sardine in 2002 and 2005 and from horse mackerel adult samples collected at the same time of those surveys. The methodology followed to estimate SSB was the same as the one for 2007, although the area covered in the egg sampling, which corresponded to the sampling grid for sardine, was smaller than in 2007.

There are different criteria that can be used to estimate the spawning fraction, such as the presence of migratory nucleus, hydrated oocytes or post-ovulatory follicles (POF). Estimates of SSB were obtained for the three years with all these criteria, and the obtained trends in SSB were parallel but with different levels. The POF criteria, assuming POF last for two days as in other species at similar temperatures (Ganias *et al.*, 2003; Hunter and Macewicz, 1985) was the one providing the lowest CV, being therefore adopted to use in the assessment. However, given the uncertainty in the absolute value of SSB, partly due to the choice of the criteria for the spawning fraction, the SSB index for the assessment must be treated as relative and a corresponding catchability parameter has to be estimated.

Still another source of uncertainty is the egg distribution area, which was roughly defined and kept fixed for the three years. In all these egg surveys, there are several transects with the presence of eggs in the most offshore station, which indicates that the area with egg presence must, in some cases, be extended further away from the coast. However, a good approximation of that area is impossible to obtain with the available data.

B.4. Commercial cpue

No commercial cpue data is used in the stock assessment.

B.5. Other relevant data

There were no other data considered at this time.

C. Assessment: data and method

Model used: AMISH (Assessment Method for the Ibero-Atlantic Stock of Horse-Mackerel).

A model similar to the one adopted by the South Pacific Regional Fishery Management Organization (SPRFMO) for the assessment of Chilean jack mackerel (*Trachurus murphyi*) was modified for application with horse mackerel. This method (Lowe *et al.*, 2009) models the population numbers-at-age as projections forward based on recruitment estimates leading up the initial population numbers-at-age (in 1992 for this case) and subsequent annual recruitment and fishing mortalities parameters. These underlying population numbers-at-age are fit through an observation model for parameter estimation via a penalized likelihood applied to a quasi-Newton minimisation routine with partial derivatives calculated by automatic differentiation (Griewank and Corliss, 1991). The automatic differentiation and minimisation routines are those from the package AD Model Builder (ADMB). A similar model is currently used in many stock assessments in North American waters (e.g., Atka mackerel, eastern Bering Sea pollock, Pacific Ocean perch). It is a simple, well tested, and widely used methodology. The population equations, model fitting components, and model settings are listed in Tables 1–4.

The approach differs from the XSA methods in that:

calculations proceed from the initial conditions to the present and into the future,

the catch-at-age is not assumed to be known exactly,

the inclusion of annual estimates of sampling variability (for both age composition and survey index precision) is allowed,

fishing mortality is separable but selection-at-age is allowed to change gradually over time,

separate components of the fishery are treated independently,

some parameters, which are assumed constant in XSA, such as the catchability coefficients associated with tuning indices, may be allowed to change over time,

statistical basis allows for careful consideration of data quality and the impact on the uncertainty of estimates.

The model begins in the first year of available data with an estimate of the population abundance-at-age. Recruitments are estimated for each year. In subsequent ages and years the abundance-at-age is reduced by the total mortality rate. This projection continues until the terminal year specified. If data are unavailable to estimate recruitment, the model will use the geometric mean value and hence can be projected to any arbitrary year (assuming specified catches).

The fishing mortality rates for each sector in the fishery are assumed to be separable into an age component (called selectivity) and a year component (called the F multiplier). The selectivity patterns are allowed to change over time. Expected catches are computed according to the usual catch equation using the determined fishing mortality rate, the assumed natural mortality rate, and the estimated population abundance described above. The statistical fitting procedure used with the model will try to match the indices and the catch-at-age. The emphasis of each of these sources of information depends on the values of the relative weights assigned to each component by the user.

The minimization processes proceeds in phases, in which groups of parameters are estimated simultaneously, while the remaining parameters are maintained at their initially assigned values. Once the objective function is minimized for a particular phase, more parameters are treated as unknown and added to those being estimated. This process of estimation in phases continues until all parameters to be estimated contribute to the objective function and the best set of all parameters that minimize the objective function value is determined.

The software code and input files is available on request.

Model Options chosen:

The objective function is the sum of a number of negative log-likelihoods generally following two types of error distributions: the lognormal and multinomial and details are listed in Table 3. The specifications of input sampling levels (in terms of sample size or variance term) are provided in Table 4.

The separability in the fishing mortality was allowed to vary according to a shift in fleet composition. An F multiplier was estimated for the first year, and was allowed to change in time by estimating deviations to this parameter for each year. The fishing mortality at each age, year and fleet resulted from the product of the F multipliers by the selectivity parameter at each age and fleet. Three selectivity vectors were estimated, corresponding to blocks of fleets sharing a similar selectivity-at-age. This is a useful feature of the model that helps to avoid overparameterisation. By looking at the plots of catch-at-age by fleet, it was decided to have a common selectivity for the purse-seine fleets, together with the Portuguese bottom-trawl fleet, another one for the artisanal fleets and a third one just for the Spanish bottom-trawl fleet. One catchability parameter for the abundance index was kept fixed over time.

The model fitting is affected by statistical weights (lambdas or inverse variance functions) as part of the objective function. Specified input variance assumptions can influence the fitting of the model, by attributing a lower or higher importance to different data sources that contribute to the objective function. The variance assumption assumed the highest precision for landings data by year and fleet. The fishery proportions-at-age for the moment were assumed to have an “effective sample size” of 100 compared to the value of ten specified for the survey estimates of age composition. The survey index data was fit assuming that the coefficient of variation was 30%. These values are typical for this type of information and diagnostic plots of model fits confirmed that they are reasonable. As more data become available, these assumptions can be modified to more appropriate and potentially time-varying values.

D. Short-term projection

Model used: Apropos designed function, named *mff*, to perform deterministic forecast, only with catch constraints (allowing the introduction of variability in the assumed recruitment values). Having the initial numbers-at-age at the beginning of the year, the total F at age in the assessment year y-1 and the assumptions we want to make on the weight-at-age, the selectivity-at-age by fleet, the maturity ogive, the natural mortality rate and the recruitment. We can project forward the population given a level of catches for the intermediate year y and for the protection year y+1. It is also possible to add some variability to the recruitments, by including a standard deviation value.

The method starts projecting the population numbers-at-age from the last assessment year with the estimated the fishing mortality rates by fleet,

$$N_0 = rec \cdot e^{\varepsilon}, \quad \varepsilon \sim N(0,\sigma)$$
$$N_1 = N_0 \cdot e^{-(M_0 + F_0)p}$$
$$N_a = N_{a-1} e^{-(M_{a-1} + F_{a-1})}, \quad a \text{ in } 2,\ldots,\text{A-1}$$
$$N_A = N_{A-1} e^{-(M_{A-1} + F_{A-1})} + N_A e^{-(M_A + F_A)}$$

where rec corresponds to the assumed recruitment level, N_a are the numbers-at-age a, M_a is the natural mortality-at-age a, F_a is the fishing mortality-at-age a, σ is the standard deviation of the recruitment and p is the proportion of the year from the recruitment time to the end of the year.

For the intermediate year in the short-term projections, the population numbers-at-age are calculated assuming catch constraints by fleet, using Pope's approximation forward,

$$\lambda = \frac{catch}{\sum_a S_a \cdot N_a \cdot W_a}, \quad proportiontothe \max imumthatcouldbecaptured$$
$$C_a = \sum_a S_a \cdot N_a \cdot \lambda$$
$$N_0 = rec \cdot e^{\varepsilon}, \quad \varepsilon \sim N(0,\sigma)$$
$$N_1 = \left(N_0 - C_0 \cdot e^{M_0 \cdot p/2}\right) e^{-M_0 \cdot p}$$
$$N_a = \left(N_{a-1} - C_{a-1} e^{M_{a-1}/2}\right) e^{-M_{a-1}}, \quad a \text{ in } 2,\ldots,\text{A-1}$$
$$N_A = \left(N_{A-1} - C_{A-1} e^{M_{A-1}/2}\right) e^{-M_{A-1}} + \left(N_A - C_A e^{M_A/2}\right) e^{-M_A}$$

where λ is the proportion to the maximum catch that could be captured, rec corresponds to the assumed recruitment, N_a are the numbers-at-age a, M_a is the natural mortality-at-age a, F_a is the fishing mortality-at-age, S_a is the selectivity-at-age, a and p is the proportion of the year from the recruitment time to the end of the year.

The source code is available on request.

Software used*:* R (www.r-project.org)

Initial stock size: the one estimated by the assessment model

Maturity: the same as in the previous year of the assessment

F and M before spawning: both of them are 0

Weight-at-age in the stock: the same as in the previous year of the assessment

Weight-at-age in the catch: assumed equal to the weight-at-age in the stock

Exploitation pattern: the one estimated in the assessment model

Intermediate year assumptions: the catches by fleet are assumed to be exactly the same as the ones in the previous year

Stock–recruitment model used: no stock–recruitment model is used, the recruitment is assumed to be stochastic in all the years (the assessment year, the intermediate and the projection year), around the geometric mean of the historical values with the same variability as the one observed in the series.

Procedures used for splitting projected catches:

E. Medium–term projections

No medium-term projection has been performed for this stock

Model used:

Software used:

Initial stock size:

Natural mortality:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock–recruitment model used:

Uncertainty models used:

Initial stock size:

Natural mortality:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock–recruitment model used:

F. Long-term projections

No long-term projection has been performed for this stock.

Model used:

Software used*:*

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Procedures used for splitting projected catches:

G. Biological reference points

Reference points have not been defined for this stock.

H. Other issues

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Table 5. Symbols definitions used for model equations.

General Definitions	Symbol/Value	Use in Catch at Age Model
Year index: i = {1992, …., 2010}	i	
Age index: j = { 0,1,2, …, 11+}	j	
Mean weight in year t by age j	Wt,j	
Maximum age beyond which selectivity is constant	Maxage	Selectivity parameterization
Instantaneous Natural Mortality	Mj	Fixed M=0.8,0.5,0.3,0.2,0.1…0.1, for j=0,1,2…11
Proportion females mature at age j	pj	Definition of spawning biomass
Sample size for proportion in year i	T_i	Scales multinomial assumption about estimates of proportion at age
Survey catchability coefficient	q^s	Prior distribution = lognormal(μ_q^s , σ_q^2)
Stock-recruitment parameters	R_0 h σ_R^2	Unfished equilibrium recruitment, steepness, variance
Virginal biomass	ϕ	Spawning biomass per recruit when there is not fishing
Estimated parameters		
φ_i □ □R_0, h, ε_i □□$, \mu^f, \mu^s, M, \eta_j^s$ □□$, \eta_j^f$ □□$, q^s$ □□		

Note that the number of selectivity parameters estimated depends on the model configuration.

Table 6. Variables and equations describing implementation of the horse mackerel assessment model.

Eq	Description	Symbol/Constraints	Key Equation(s)
1)	Survey abundance index (s) by year (Δ^s represents the fraction of the year when the survey occurs)	I_i^s	$I_i^s = q^s \sum_{j=0}^{11} N_{ij} W_{ij} S_j^s e^{-\Delta^s Z_{ij}}$
2)	Catch biomass by year	C_i	$\hat{C}_{ij}^f = \sum_{j=0}^{11} N_{ij} W_{ij} \frac{F_{ij}^f}{Z_{ij}} (1 - e^{-Z_{ij}})$
3)	Proportion at age j, in year i	$P_{ij}, \sum_{j=0}^{11} P_{ij} = 1.0$	$p_{ij}^f = \frac{\hat{C}_{ij}^f}{\sum_j \hat{C}_{ij}^f}$
4)	Initial numbers at age	j = 0	$N_{1992,j} = e^{\mu_R + \varepsilon_{1992}}$
5)		0 < j < 10	$N_{1992,j} = e^{\mu_R + \varepsilon_{1993-j}} \prod_{j=1}^{j} e^{-M}$
6)		j = 11+	$N_{1992,11} = N_{1992,10} \left(1 - e^{-M}\right)^{-1}$
7)	Subsequent years (i >1992)	j = 0	$N_{i,2} = e^{\mu_R + \varepsilon_i}$
8)		0 < j < 10	
9)		j = 11+	$N_{i,11} = N_{i-1,10} e^{-Z_{i-1,10}} + N_{i-1,11} e^{-Z_{i-1,11}}$
10)	Year effect and individuals at age 2 and i = 1981, …, 2010	$\varepsilon_i, \sum_{i=1981}^{2010} \varepsilon_i = 0$	$N_{i,0} = e^{\mu_R + \varepsilon_i}$
11)	Index catchability Mean effect Age effect	μ^s, μ^f $\eta_{ij}, \sum_{j=0}^{11} \eta_{ij} = 0$	$q_i^s = e^{\mu^s}$ $s_j^s = e^{\eta_j^s}$ $j \le$ maxage $s_j^s = e^{\eta_{\text{maxage}}^s}$ $j >$ maxage
12)	Instantaneous fishing mortality		$F_{ij}^f = e^{\mu^f + \eta_j^f + \varphi_i}$
13)	Mean fishing effect	μ^f	
14)	Annual effect of fishing mortality in year i	$\varphi_i, \sum_{i=1992}^{2010} \varphi_i = 0$	
15)	age effect of fishing (regularized) In year time variation allowed In years where selectivity is constant over time	η_{ij}^f, $\sum_{j=2}^{12^+} \eta_{ij} = 0$ $\eta_{i,j}^f = \eta_{i-1,j}^f$	$s_{ij}^f = e^{\eta_j^f}$, $j \le$ maxage $s_{ij}^f = e^{\eta_{\text{maxage}}^f}$ $j >$ maxage $i \ne$ change year
16)	Natural Mortality vector	Mj	0.8 0.5 0.3 0.2,0.1…0.1 for ages 0 - 11
17)	Total mortality		$Z_{ij} = \sum_f F_{ij}^f + M$

Eq	Description	Symbol/Constraints	Key Equation(s)
17)	Spawning biomass (note spawning taken to occur at mid of January)	Bi	$B_i = \sum_{j=0}^{11} N_{ij} e^{-\frac{0.5}{12} Z_{ij}} W_{ij} p_j$
18)	Recruitments (Beverton-Holt form) at age 0.	$\tilde{R}_i$	$\tilde{R}_i = \frac{\alpha B_i}{\beta + B_i}$, $\alpha = \frac{4hR_0}{5h-1}$ and $\beta = \frac{B_0(1-h)}{5h-1}$ where $B_0 = R_0 \varphi$ $\varphi = \sum_{j=2}^{12} e^{-M(j-1)} W_j p_j + \frac{e^{-12M} W_{12} p_{12}}{1-e^{-M}}$ h=0.8

Table 7. Specification of objective function that is minimized (i.e., the penalized negative of the log-likelihood).

	Likelihood /penalty component		Description / notes
44)	Catch biomass likelihood	$L_1 = \sum_f \lambda_4^f \sum_{i=1992}^{2010} \ln\left(\frac{C_i^f}{\hat{C}_i^f}\right)^2$	Fit to catch biomass in each year
19)	Abundance indices	$L_2 = \sum_s \lambda_1^s \sum_i \ln\left(\frac{I_i^s}{\hat{I}_i^s}\right)^2$	Survey abundances
20)	Proportion at age likelihood	$L_k = \sum_{k,i,j} \tau_i^k P_{ij}^k \ln\left(\hat{P}_{ij}^k\right) \qquad k = 3,4$	k=3 for the fishery, k=4 for the survey
21)	Penalty on smoothness for selectivities	$L_k = \sum_k \lambda_k \sum_{j=0}^{11} \left(\eta_{j+2}^l + \eta_j^l - 2\eta_{j+1}^l\right)^2 \; k = 6,9$	Smoothness (second differencing), Note: k=6 for the fishery, k=9 for the survey
22)	Penalty on recruitment regularity	$L_{11} = \lambda_{11} \sum_{i=1981}^{2010} \varepsilon_i^2$	Influences estimates where data are lacking (e.g., if no signal of recruitment strength is available, then the recruitment estimate will converge to median value).
23)	Recruitment curve penalty	$L_6 = \lambda_6 \sum_{i=1992}^{2010} \ln\left(\frac{N_{i,0}}{\tilde{R}_i}\right)^2$	Conditioning on stock-recruitment curve over period 1992–2007 (but reduced to have negligible effect on estimation).
24)	Overall objective function to be minimized	$\dot{L} = \sum_k L_k$	

Table 8. Input variance □ or sample size (τ □□assumptions and corresponding penalties (□□ used on log-likelihood functions in the base model.

L	Abundance index	□	τ	□L
1	Landings	0.05	-	200
2	Combined index	0.3	-	5.556
3	Fishery age composition	-	100	-
4	Survey age composition	-	10	-
5	Time-change in fishery selectivities	0.8		0.78
6	Fishery age-specific penalties	1.0	-	0.5
7	Fishery descending selectivity-with-age penalty	10	-	0.1
8	Time-change in survey selectivities	0.8		0.78
9	Survey age-specific penalties	1.0	-	0.5
10	Survey descending selectivity-with-age penalty	10	-	0.1
11	Recruitment regularity	10	-	0.1
12	S-Recruitment curve fit (for period 1992–2007, scale only)	1.9	-	0.14

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1992–2008	0–11+	Si
Canum	Catch-at-age in numbers	1992–2008	0–11+	Si
Weca	Weight-at-age in the commercial catch	1992–2008	0–11+	Si
West	Weight-at-age of the spawning stock at spawning time.	1992–2008	0–11+	Si
Mprop	Proportion of natural mortality before spawning	1992–2008	0–11+	Si
Fprop	Proportion of fishing mortality before spawning	1992–2008	0–11+	No
Matprop	Proportion mature-at-age	1992–2008	0–11+	No
Natmor	Natural mortality	1992–2008	0–11+	No
	Spanish-Portuguese bottom-trawl survey	1992–2009	0–11+	

5.5 Stock Annex: Sardine Subarea VII and VIIIabd

Stock	Sardine Subarea VII + VIIIabd
Working Group	WGHANSA
Date	4th to 8th of February, 2013
Revised at	WKPELA
Authors	E. Duhamel, L. Ibaibarriaga, J. Massé, L. Pawlowski, M. Santos and A. Uriarte.

A. General

A.1. Stock definition

European sardine (*Sardine pilchardus* Walbaum, 1792) has a wide distribution extending in the Northeast Atlantic from the Celtic Sea and North Sea in the north to Mauritania in the south. Populations of Madeira, the Azores and the Canary Islands are at the western limit of the distribution (Parrish *et al*., 1989). Sardine is also found in the Mediterranean and the Black Seas. Changing environmental conditions affect sardine distribution, with fish having been found as far south as Senegal during episodes of low water temperature (Corten and van Kamp, 1996; Binet *et al*., 1998).

Sardine in Celtic Seas (VIIabcfgjk), English Channel (VIId, VIIe, VIIh) and in Bay of Biscay (VIIIabd) are considered to belong to the same stock from a genetic point of view. Therefore, the sardine stock in VIIIabd and VII can be considered as a single stock unit but it is important to note that there should be some distinction within the stock structure to take account of some regional differences between fisheries as there are some locally important fisheries operating in some area.

The availability of data strongly differs between the northern (Celtic Seas, English Channel) and the southern component (Bay of Biscay). Additionally, each area presents different historical exploitation patterns. Therefore analysis and management advice between the areas may differ, even if the advice covers the whole stock.

A.2. Fishery

There are currently no management measures implemented for this stock. The fisheries appear to be regulated by market price. Some fisheries (e.g. French fleets in the Bay of Biscay) have set their own local management in order to sustain correct market prices which imply targeting fish of certain sizes and limit to the total amount of catch. The absence of TAC is currently not seen as a problem for the management of those fisheries as the demand of sardine is considered to be low.

Divisions VIIIabd (Bay of Biscay)

An update of the French and Spanish catch dataseries in Divisions VIIIa and VIIIb (from 1983 and 1996 for France and Spain, respectively) including 2011 catches was presented to this benchmark. Spanish catches are taken by purse seines from the Basque Country operating only in Division VIIIb. Spanish landings peaked in 1998 and 1999 with almost 8 thousand tonnes but have decreased until 2010 to below 1 thousand tonnes. The Spanish fishery takes place mainly during March and April and in the fourth quarter of the year.

French catches have increased along the series, with values ranging from 4400 tonnes in 1983 to 23 000 tonnes in 2011 (Figure A.2.1). A total of 90% of the catches are taken by purse seiners while the remaining 10% is reported by pelagic trawlers (mainly pair trawlers). A substantial part of the French catches originates in Divisions VIIh and VIIe, but these catches have been assigned to Division VIIIa due to their very concentrated location at the boundary between VIIIa, VIIh and VIIe.

Spanish catches were unusually high prior 1989 where a strong drop occurs. The reason of this drop is unknown and likely to be related to some data aggregation issues which make any uses of landings prior this year uncertain.

Both purse seiners and pelagic trawlers target sardine in French waters. Average vessel length is about 18 m. Purse seiners operate mainly in coastal areas (<10 nautical miles) while trawlers are allowed to fish within 3 nautical miles from the coast. Both pair trawlers and purse seiners operate close to their base harbour when targeting sardine. The highest catches are taken in the summer months. Almost all the catches are taken in southwest Brittany.

While French catches in Divisions VIIIa and VIIIb are constituted by fish of a wide range of sizes with a peak at 20 cm length, sardine taken by Spanish vessels show a narrower range of sizes but with a peak at similar length size.

The Bay of Biscay sardine fisheries overlaps with VIIe and VIIh (statistical rectangle 25E4, 25E5). Catches in those rectangles are assumed to be of sardine from Bay of Biscay. Therefore landings in Bay of Biscay and English Channel are corrected to take account of this phenomenon by adding the catches in those rectangles to the Bay of Biscay landings time-series.

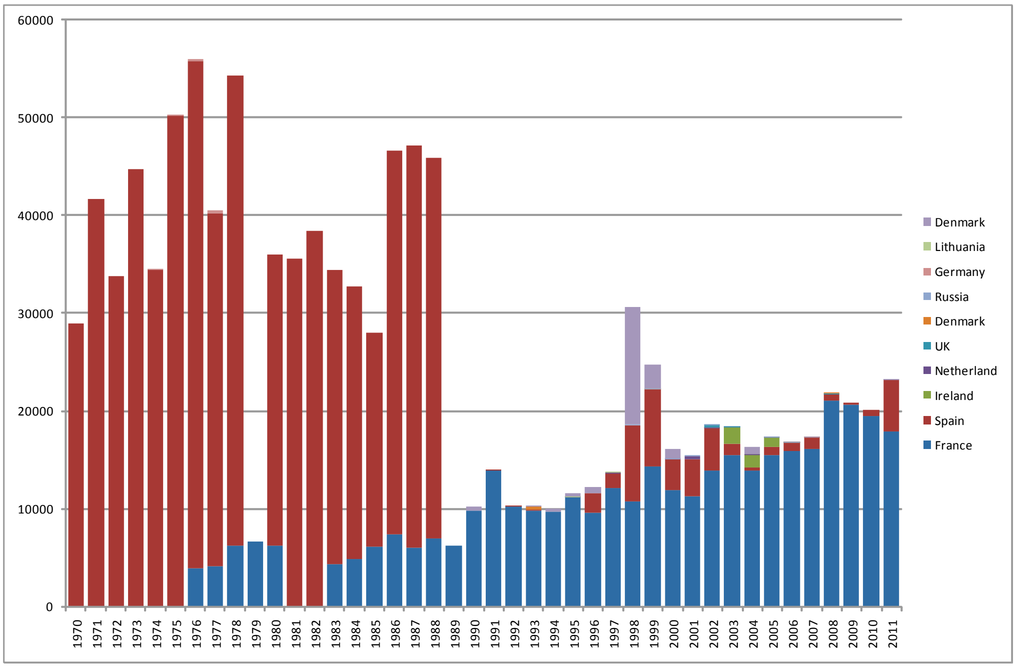


Figure A.2.1. Historical time-series of landings of sardine per country in the Bay of Biscay.

Subareas VIIdeh (English Channel and VIIh)

Most of the catches are concentrated close to or in the English Channel (VIId, VIIe, VIIh) with major landings from France and Netherlands, other catches being taken by England and Wales. Little information was available from other countries operating in that subarea. Catches have substantially oscillated with time and between countries from 25 000 to less than 2000 tons. This region has been harvested substantially in the past by various fleets (Figure A.2.2) from various countries that are no longer operating in those waters. The peak of fishing activity was in the early 1990s at around 25 000 tons. Over the last decades, the landings have been between nearly 5000 to 11 000 tons with no particular trends. The English Channel is after Bay of Biscay the second fishing area for sardine.

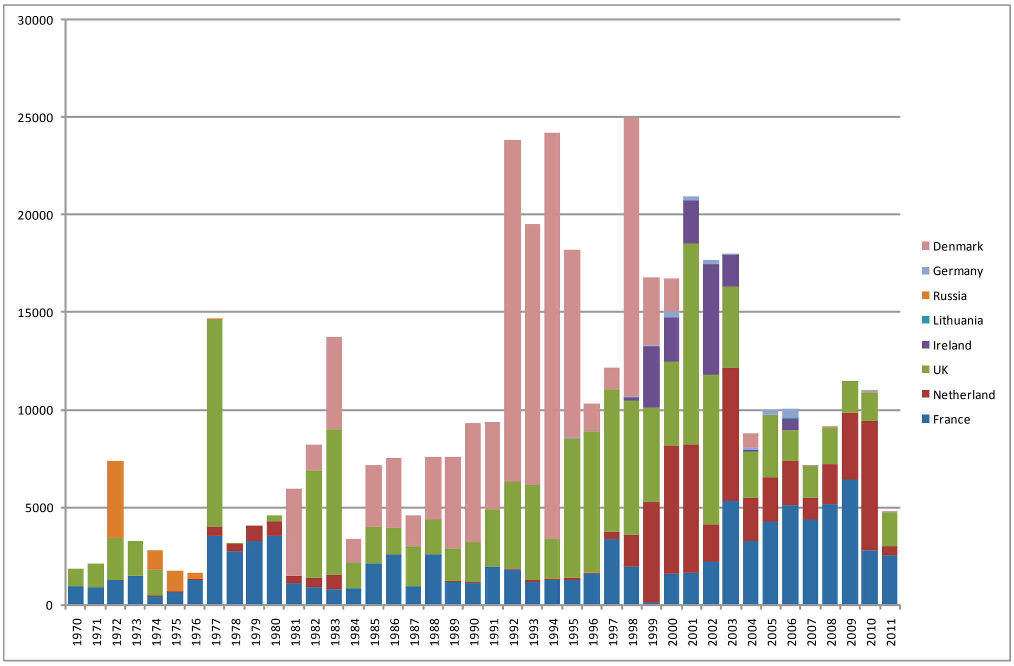


Figure A.2.2. Historical time-series of landings of sardine per country in the English Channel and VIIh.

As mentioned for the Bay of Biscay, catches in rectangles 25E4, 25E5 are removed from the official landings and added to the catches in the Bay of Biscay to take account of the mixing at the borders of Division VIIIa and VIIh and VIIe.

Subareas VIIabcfgjk (Celtic Seas)

Catches in this area are very low.

A.3. Ecosystem aspects

Sardine is prey of a range of fish and marine mammal species which take advantage of its schooling behaviour and availability. Sardine has been found to be important in the diet of common dolphins (*Delphinus delphis*) in Galicia (NW Spain) (Santos *et al.*, 2004), Portugal (Silva, 2003) and the Atlantic French coast (Meynier, 2004). Recent studies of consumption of common dolphins in Galician (Santos *et al.*, 2011) waters give figures ranging from almost 6000 tons to more than 9000 tons of sardine, which represents a rather small proportion of the combined Spanish and Portuguese annual landings of sardine from ICES Areas VIIIc and IXa (6–7%).There are also other species feeding on sardine, although to a lesser extent, such as: harbour porpoise (*Phocoena phocoena*), bottlenose dolphin (*Tursiops truncatus*), striped dolphin (*Stenella coeruleoalba*), and white-sided dolphin (*Lagenorhynchus acutus*) (e.g. Santos *et al.*, 2007).

B. Data

B.1. Commercial catches

Landings data have been available for since 1950 on various aggregation levels. Data are considered to be accurate for all countries starting 1989 within the whole area. Discards were measured only in 2012 and were low based on the French Observers at sea program in the Bay of Biscay and hence not included in the assessment. In the past (late eighties and early nineties for the French Pelagic trawlers and sixties and seventies for the Spanish Purse seine fleet) they seemed to be more relevant (according to disputes among fishermen), but were never quantified. Length distribution of discards are also available from Netherlands in the English Channel for 2011.

B.2. Biological

Catches-at-length and catches-at-age are known since 1984 for Spain and since 2002 for France in the Bay of Biscay. Because of the availability of the datasets only the period starting in 2000 is used. They are obtained by applying to the monthly Length distributions half year or quarterly ALKs. Biological sampling of the catches has been generally sufficient, and useful to have a better knowledge of the age structure of the catches during the second semester in the North of the Bay of Biscay. Complete age composition and mean weight-at-age on half year basis, were each year reported in ICES (WGHANSA report, ICES 2012).

Age reading is considered accurate. The most recent cross reading exchanges and workshop between Spain and France (but other countries, too) took place in 2011 (WKARAS report, ICES 2011). The overall level of agreement and precision in sardine of the Bay of Biscay age reading determinations seems to be satisfactory: Most of the sardine otoliths were well classified by most of the readers during the 2011 workshop (with an average agreement 75% and a CV of 14%).

Sardines are mature in their 1st year of life.

Growth in weight and length are routinely obtained from surveys and from the monitoring of the fishery.

Natural mortality is fixed at 0.33 based on the assessment for sardine in VIIIc and IXa. This parameter is considered to vary between years and ages, but it is assumed to be constant for the assessment of the stock.

B.3. Surveys

Relevant surveys are available for the Bay of Biscay only. Some sardines are caught during the various demersal surveys (e.g FR-IBTS) occuring each year in the Celtic Seas, Bay of Biscay and English Channel but those catches are not substantial enough to be considered as indicators of the stock status.

Some abundance indices are available every year for the Bay of Biscay through two spring surveys based on acoustic surveys (PELGAS) and DEPM (Daily egg production method - BIOMAN).

The population present in the Bay of Biscay is monitored by the two annual surveys carried out in spring on the spawning stock, namely, the Daily Egg Production Method and the Acoustics surveys (regularly since 1989, although surveys were also conducted in 1983, 1984 and some in the seventies) (Massé, 1988; 1994; 1996). Both surveys provide spawning biomass and population-at-age estimates.

This survey based monitoring system provides population estimates by the middle of the year, when a small part of the annual catches have been already taken.

B.3.1. Sardine acoustic indices (PELGAS survey)

Acoustic surveys are carried out every year in the Bay of Biscay in spring on board the French research vessel Thalassa since 1997. The objective of PELGAS surveys is to study the abundance and distribution of pelagic fish in the Bay of Biscay.

These surveys are connected with Ifremer programmes on data collection for monitoring and management of fisheries and ecosystemic approach for fisheries. This task is formally included in the first priorities defined by the Commission regulation EU N° 199/2008 of 06 November 2008 establishing the minimum and extended Community programmes for the collection of data in the fisheries sector and laying down detailed rules for the application of Council Regulation (EC) No 1543/2000. These surveys must be considered in the frame of the Ifremer fisheries ecology action "resources variability" which is the French contribution to the international Globec programme. It is planned with Spain and Portugal in order to have most of the potential area to be covered from Gibraltar to Brest with the same protocol for sampling strategy. Data are available for the ICES working groups WGHANSA, WGWIDE and WGACEGG.

In 2003, survey data are considered less reliable because of unusual environmental conditions linked to the heat wave over Europe. Results this year were considered not representative of the true status of the stock.

B.3.1.1. PELGAS Method and sampling strategy

In the frame of an ecosystemic approach, the pelagic ecosystem is characterised at each trophic level. In this objective, to assess an optimum horizontal and vertical description of the area, two types of actions are combined:

- Continuous acquisition by storing acoustic data from five different frequencies and pumping seawater under the surface in order to evaluate the number of fish eggs using a CUFES system (Continuous Under-water Fish Eggs Sampler); and
- Discrete sampling at stations (by trawls, plankton nets, CTD). Satellite imagery (temperature and sea colour) and modelisation will be also used before and during the cruise to recognise the main physical and biological structures and to improve the sampling strategy. Concurrently, a visual counting and identification of cetaceans and birds (from board) is carried out in order to characterise the higher level predators of the pelagic ecosystem.

Satellite imagery (temperature and sea colour) and modelisation are also used before and during the cruise to recognise the main physical and biological structures and to improve the sampling strategy.

The strategy of the survey is the same for the whole series (since 2000).

- Acoustic data were collected along systematic parallel transects perpendicular to the French coast (Figure B.3.1.1). The length of the ESDU (Elementary Sampling Distance Unit) was 1 mile and the transects were uniformly spaced by 12 nautical miles covering the continental shelf from 20 m depth to the shelf break.

Acoustic data were collected only during the day because of pelagic fish behaviour in this area. These species are usually dispersed very close to the surface during the night and so "disappear" in the blind layer for the echo sounder between the surface and 8 m depth.

Two echo-sounders are usually used during surveys (SIMRAD EK60 for vertical echo-sounding and MARPORT on the pelagic trawl). Since 2009 the SIMRAD ME70 is used for multibeam visualisation. Energies and samples provided by split beam transducers (six frequencies EK60, 18, 38, 70, 120, 200 and 333 kHz), simple beam (MARPORT) and multibeam echosounder were simultaneously visualised, stored using the MOVIES+ software and at the same standard HAC format.

The calibration method is the same that the one described for the previous years (see W.D. 2001) with a tungsten sphere hanged up 20 m below the transducer and is generally performed at anchorage in front of Machichaco Cap or in the Douarnenez Bay, on the west side of Brittany, in optimal meteorological conditions.

Acoustic data are collected by Thalassa along the totality of the daylight route from which about 2000 nautical miles on one way transect are usable for assessment. Fish are measured on board (for all species) and otoliths (for anchovy and sardine) are collected for age determinations.

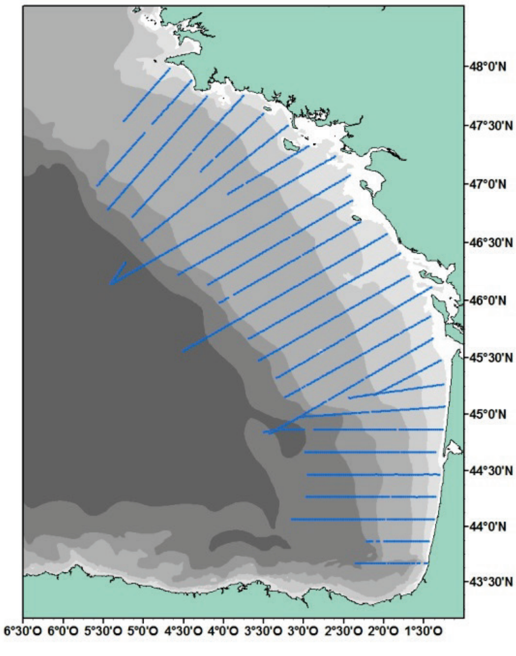


Figure B.3.1.1. The acoustic transects network of the PELGAS survey.

B.3.1.2. Echoes scrutinizing

Most of the acoustic data along the transects are processed and scrutinised during the survey and are generally available one week after the end of the survey. Acoustic energies (Sa) are cleaned by sorting only fish energies (excluding bottom echoes, parasites, plankton, etc.) and classified into several categories of echotraces according to the year fish (species) structures.

D1 – energies attributed to mackerel, horse mackerel, blue whiting, various demersal fish, corresponding to cloudy schools or layers (sometimes small dispersed points) close to the bottom or of small drops in a 10 m height layer close to the bottom.

D2 – energies attributed to anchovy, sprat, sardine and herring corresponding to the usual echo-traces observed in this area since more than 15 years, constituted by schools well defined, mainly situated between the bottom and 50 meters above. These echoes are typical of clupeids in coastal areas and sometimes more offshore.

D3 – energies attributed to blue whiting, myctophids and boarfish offshore, just closed to the shelf-break and on the platform in the north.

D4 – energies attributed to sardine, mackerel and anchovy corresponding to small and dense echoes, very close to the surface.

D8 – energies attributed exclusively to sardine (big and very dense schools).

B.3.1.3. Data processing

The global area is split into several strata where coherent communities are observed (species associations) in order to minimise the variability due to the variable mixing of species. For each stratum, a mean energy is calculated for each type of echoes and the area measured. A mean haul for the strata is calculated to get the proportion of species into the strata. This is obtained by estimating the average of species proportions weighted by the energy surrounding haul positions. Energies are therefore converted into biomass by applying catch ratio, length distributions and TS relationships. The calculation procedure for biomass estimate and variance is described in Petitgas *et al*., 2003.

The TS relationships used since 2000 are still the same and as following:

Sardine, anchovy & sprat: TS = 20 Log L – 71.2

Horse mackerel: TS = 20 Log L – 68.7

Blue whiting: TS = 20 Log L – 67.0

Mackerel: TS = 20 Log L – 86.0

The mean abundance per species in a stratum (tons m.n.$^{-2}$) is calculated as:

$$M_e(k) = \sum_D \bar{s}_A(D,k)\bar{X}_e(D,k)$$

and total biomass (tons) by: $B_e = \sum_k A(k)Me(k)$

where,

k : strata index

D : echo type

e : species

$\mathbf{S_A}$: Average S_A (NASC) in the strata (m2/n.mi.2)

$\mathbf{X_e}$: species proportion coefficient (weighted by energy around each haul) (tons m^{-2})

A : area of the strata (m.n.[2])

Then variance estimate is:

$$Var.M_e(k)=\sum_D \bar{s}_A^{\,2}(D,k)Var[X_e(D,k)]/n.cha(k)+\overline{X}_e^{\,2}\,\mathrm{var}[s_A(D,k)]/n.esu(D,k)$$

$$Var.B_e=\sum_k A^2(k)Var.Me(k)$$

$$cv=\sqrt{Var.Be}/Be$$

At the end, density in numbers and biomass by length and age are calculated for each species in each ESDU according to the nearest haul length composition. These numbers and biomass are weighted by the biomass in each stratum and data are used for spatial distributions by length and age.

The detailed protocol for these surveys (strategy and processing) is described in Annex 6 of WGACEGG report (ICES 2009).

B.3.2 Anchovy Daily Egg Production Method (BIOMAN Survey)

B.3.2.1 the DEPM model

The sardine spawning–stock biomass estimates is derived according to Parker (1980) and Stauffer and Picquelle (1980) from the ratio between daily production of eggs in the sea and the daily specific fecundity of the adult population:

$$SSB = P_{tot}/DF = \frac{P_0 \cdot A+}{k \cdot R \cdot F \cdot S/W}$$

Equation 1

Where,

SSB = Spawning–stock biomass in metric tons

P_{tot} = Total daily egg production in the sampled area

P_0 = daily egg production per surface unit in the sampled area

A+ = Spawning area, in sampling units

DF = Daily specific fecundity. $DF = \frac{k \cdot R \cdot F \cdot S}{W}$

W = Average weight of mature females in grams,

R = Sex ratio, fraction of population that are mature females, by weight.

F = Batch fecundity, numbers of eggs spawned per mature females per batch

S = Fraction of mature females spawning per day

k = Conversion factor from gram to metric tons (10^6)

An estimate of an approximate variance and bias for the biomass estimator derived using the *delta* method (Seber, 1982, *in* Stauffer and Picquelle, *op. cit.*) was also developed by the latter authors.

Population estimates of numbers-at-age are derived as follows:

$$N_a = N \cdot E_a = \frac{SSB}{W_t} \cdot E_a$$

Equation 2

Where,

N$_a$ = Population estimate of numbers-at-age *a*.

N = Total spawning–stock estimate in numbers. $N = \frac{SSB}{W_t}$

SSB = spawning–stock biomass estimate.

W$_t$ = average weight of anchovies in the population.

E$_a$ = Relative frequency (in numbers) of age *a* in the population.

Variance estimate of the sardine stock in numbers-at-age and total is derived applying the delta method.

B.3.2.2 Collection of plankton samples

Every year the area covered to collect the plankton samples is the southeast of the Bay of Biscay taking in advance the anchovy survey in the Bay of Biscay.

Predetermined distribution of stations is shown in Figure B.3.1.2.1. The strategy of egg sampling is as follow: a systematic central sampling scheme with random origin and sampling intensity depending on the egg abundance found (Motos, 1994). Stations are located every 3 miles along 15-mile-apart transects perpendicular to the

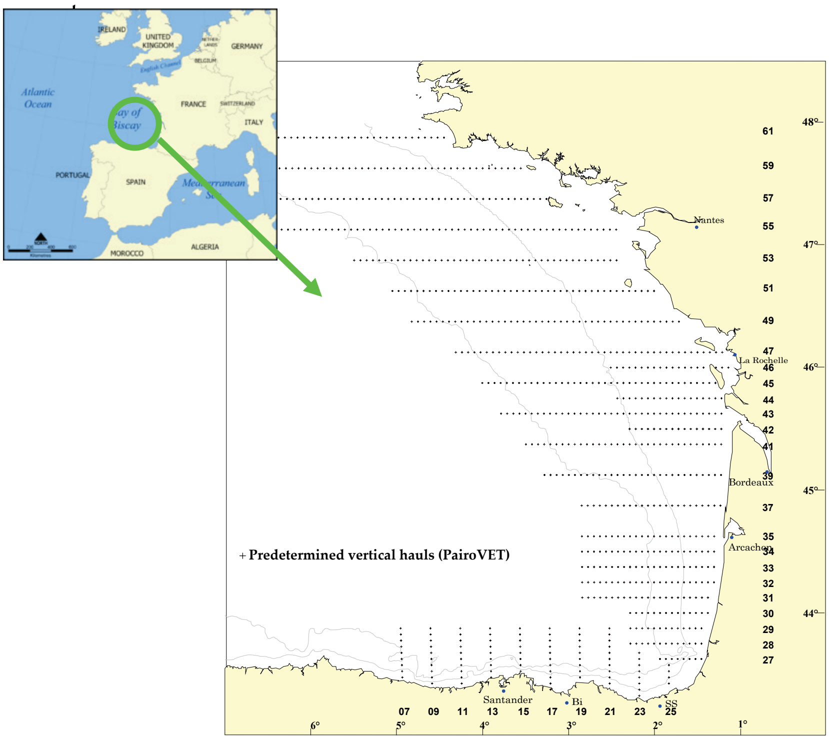


Figure B.3.1.2.1. Predetermined stations of the vertical hauls (PairoVET) that could be performed during the survey.

At each station a vertical plankton haul is performed using a PairoVET net (Pair of Vertical Egg Tow, Smith *et al*., 1985 in Lasker, 1985) with a net mesh size of 150 µm for a total retention of the sardine eggs under all likely conditions. The net is lowered to a maximum depth of 100 m or 5 m above the bottom in shallower waters. After allowing 10 seconds at the maximum depth for stabilisation, the net is retrieved to the surface at a speed of 1 m s-1. A 45 kg depressor is used to allow for correctly deploying the net. "G.O. 2030" flowmeters are used to detect sequential clogging of the net during a series of tows.

Immediately after the haul, the net is washed and the samples obtained are fixed in formaldehyde 4% buffered with sodium tetra borate in seawater. After six hours of fixing, anchovy, sardine and other eggs species are identified, sorted out and count on board. Afterwards, in the laboratory, a percentage of the samples are checked to assess the quality of the sorting made at sea. According to that, a portion of the samples are sorted again to ensure no eggs were left in the sample. In the laboratory, sardine eggs are classified into morphological stages (adapted from Gamulin and Hure, 1955).

The Continuous Underway Fish Egg Sampler (CUFES, Checkley *et al*., 1997) is used to record the eggs found at 3 m depth with a net mesh size of 350 µm. The CUFES system has a CTD to record simultaneously temperature and salinity at 3 m depth, a flowmeter to measure the volume of the filtered water, a fluorimeter and a GPS (Geographical Position System) to provide sampling position and time. All these data are registered at real time using the integrated EDAS (Environmental Data Acquisition System) with custom software.

During the survey, the anchovy, sardine and other eggs are recorded per PairoVET station and the area where sardine eggs occurred is quantified. Following the systematic central sampling scheme (Cochran, 1977) each station is located in the centre of a rectangle. Egg Abundance found at a particular station is assumed to represent the abundance in the whole rectangle. The area represented by each station is measured. A standard station has a surface of 45 squared nautical miles (154 km^2) = 3 (distance between two consecutive stations) x 15 (distance between two consecutive transects) nautical miles. Since sampling is adaptive, station area changed according to sampling intensity and the cut of the coast.

Sample depth, temperature, salinity and fluorescence profiles are obtained in every station using a CTD RBR-XR420 coupled to the PairoVET. In addition, surface temperature and salinity is recorded in each station with a manual termosalinometer WTW LF197.Moreover current data are obtained all along the survey with an ADCP (Acoustic Doppler Current Profiles). In some point determinate previously to the survey, water is filtered from the surface to obtain chlorophyll samples to calibrate the chlorophyll data.

B.3.2.3 Collection of adult samples

Since 2008 each three years adults are being obtained from a research vessel with pelagic trawl taking in advance the anchovy survey.

The research vessel pelagic trawler covers the same area as the plankton vessel. When the plankton vessel encountered areas with sardine eggs, the pelagic trawler is directed to those areas to fish. In each haul 100 individuals of each species are measure. Immediately after fishing, sardine is sorted from the bulk of the catch and a sample is selected at random. A minimum of 60 anchovies are weighted, measured and sexed and from the mature females the gonads of 25 non-hydrated females (NHF) are preserved. If the target of 25 NHF is not completed 10 more anchovies are taken at random and process in the same manner. Sampling is stopped when 120 anchovies have to be sexed to achieve the target of 25 NHF. Otoliths are extracted on board and read in the laboratory to obtain the age composition per sample.

B.3.2.4 Total daily egg production estimates

Since 1999 the sardine eggs were counted but only were staged in years 1999, 2002, 2008 and 2011.

In years without egg stages it was considered the total abundances of eggs defined as the sum along all the stations of the sardine eggs in each station multiplied by the area each station represents.

In years when sardine eggs are sorted and staged (1999, 2002, 2008 and 2011), it is possible to estimate total daily egg production (P_{tot}). This is calculated as the product between the daily egg production (P_0) and the spawning area (SA).

$$P_{tot} = P_0 \, SA$$

A standard sampling station represents a surface of 45 nm^2 (i.e. 154 km^2). Since the sampling was adaptive, area per station changes according to the sampling intensity and the cut of the coast. The total area is calculated as the sum of the area represented by each station. The spawning area (SA) is delimited with the outer zero sardine egg stations but it can contain some inner zero stations embedded. The spawning area is computed as the sum of the area represented by the stations within the spawning area.

The daily egg production per area unit (P0) was estimated together with the daily mortality rate (Z) from a general exponential decay mortality model of the form:

(2)
$$P_{i,j} = P_0 \exp\left(-Z \, a_{i,j}\right),$$

where Pi,j and ai,j denote respectively the number of eggs per unit area in cohort j in station i and their corresponding mean age. Let the density of eggs in cohort j in station i, Pi,j, be the ratio between the number of eggs Ni,j and the effective sea area sampled Ri (i.e. $P_{i,j} = N_{i,j} / R_i$). The model was written as a generalised linear model (GLM, McCullagh and Nelder, 1989; ICES, 2004) with logarithmic link function:

(3)
$$\log\left(E[N_{i,j}]\right) = \log(R_i) + \log\left(P_0\right) - Z \, a_{i,j},$$

where the number of eggs of daily cohort *j* in station *i* (N_{ij}) was assumed to follow a negative binomial distribution. The logarithm of the effective sea surface area sampled ($\log(R_i)$) was an offset accounting for differences in the sea surface area sampled and the logarithm of the daily egg production $\log(P_0)$ and the daily mortality Z rates were the parameters to be estimated.

The eggs collected at sea and sorted into morphological stages had to be transformed into daily cohort frequencies and their mean age calculated in order to fit the above model. For that purpose the Bayesian ageing method described in ICES (2004), Stratoudakis *et al.*, (2006) and Bernal *et al.*, (2011) was used. This ageing method is based on the probability density function (pdf) of the age of an egg *f(age | stage, temp),* which is constructed as:

(4)
$$f(age \mid stage, temp) \propto f(stage \mid age, temp) \, f(age).$$

The first term f(stage | age, temp) is the pdf of stages given age and temperature. It represents the temperature dependent egg development, which is obtained by fitting a multinomial model like extended continuation ratio models (Agresti, 1990) to data from temperature dependent incubation experiments (Ibaibarriaga *et al*., 2007, Bernal *et al*., 2008). The second term is the prior distribution of age. A priori the probability of an egg that was sampled at time τ of having an age is the product of the probability of an egg being spawned at time τ - age and the probability of that egg surviving since then (exp(-Z age)):

(5) $$f(age) \propto f(spawn = \tau - age)\exp(-Z\ age).$$

The pdf of spawning time f(spawn=τ - age) allows refining the ageing process for species with spawning synchronicity that spawn at approximately certain times of the day (Lo, 1985a; Bernal *et al*., 2001). Sardine spawning time was assumed to be normally distributed with mean at 21:00h GMT and standard deviation of 3 (ICES, 2004). The peak of the spawning time was also used to define the age limits for each daily cohort (spawning time peak plus and minus 15 hours). Details on how the number of eggs in each cohort and the corresponding mean age are computed from the pdf of age are given in Bernal *et al*. (2011). The incubation temperature considered was the one obtained from the CTD at 10 m in the way up.

Given that this ageing process depends on the daily mortality rate which is unknown, an iterative algorithm in which the ageing and the model fitting are repeated until convergence of the Z estimates was used (Bernal *et al*., 2001; ICES, 2004; Stratoudakis *et al*., 2006). The procedure is as follows:

Step 1. Assume an initial mortality rate value;

Step 2. Using the current estimates of mortality calculate the daily cohort frequencies and their mean age;

Step 3. Fit the GLM and estimate the daily egg production and mortality rates. Update the mortality rate estimate;

Step 4. Repeat steps (1)–(3) until the estimate of mortality converged (i.e. the difference between the old and updated mortality estimates was smaller than 0.0001).

Incomplete cohorts, either because the bulk of spawning for the day was not over at the time of sampling, or because the cohort was so old that its constituent eggs had started to hatch in substantial numbers, were removed in order to avoid any possible bias. At each station, younger cohorts were dropped if they were sampled before twice the spawning peak width after the spawning peak and older cohorts were dropped if their mean age plus twice the spawning peak width was over the critical age at which less than 99% eggs were expected to be still unhatched. Once the final model estimates were obtained the coefficient of variation of P0 was given by the standard error of the model intercept (log(P0)) (Seber, 1982) and the coefficient of variation of Z was obtained directly from the model estimates.

The analysis was conducted in R (www.r-project.org). The "MASS" library was used for fitting the GLM with negative binomial distribution and the "egg" library (http://sourceforge.net/projects/ichthyoanalysis/) for the ageing and the iterative algorithm.

B3.2.5 Adult parameters, daily fecundity and SSB estimates

In 2008 and 2011 adult samples were collected within the same day as the egg sampling. These samples are used to obtain adult parameters to estimate the daily fecundity, i.e. batch fecundity, spawning fraction, average female weight and sex ratio.

These adult parameters are estimates as follows:

Sex Ratio (R): It is calculate as the average sample ratio between the average female weight and the sum of the average female and male weights of the anchovies in each of the samples.

Total weight of hydrated females is corrected for the increase of weight due to hydration. Data on gonad-free-weight (Wgf) and correspondent total weight (W) of nonhydrated females is fitted by a linear regression model. Gonad-free-weight of hydrated anchovies is then transformed to total weight by applying the following equation:

$$W = -a + b * W_{gf}$$

For the **Batch fecundity (F)** estimates i.e. number of eggs laid per batch and female, the hydrated egg method was followed (Hunter et al, 1985). The number of hydrated oocytes in gonads of a set of hydrated females is counted. This number is deduced from a sub-sampling of the hydrated ovary: Three pieces of approximately 50 mg are removed from different parts of each ovary, weighted with precision of 0.1 mg and the number of hydrated oocytes counted. Sanz and Uriarte (1989) showed that three tissue samples per ovary are adequate to get good precision in the final batch fecundity estimate and the location of sub-samples within the ovary do not affect it. Finally the number of hydrated oocytes in the subsample is raised to the total gonad of the female according to the ratio between the weights of the gonad and the weight subsampled.

A linear regression between female weight and batch fecundity is established for the subset of hydrated females and used to calculate the batch fecundity of all mature females. The average of the batch fecundity estimates for the females of each sample as derived from the gonad free weight–eggs per batch relationship is then used as the sample estimate of batch fecundity.

Moreover, an analysis is conducted to verify if there are differences in the batch fecundity if strata are defined to estimate SSB.

To estimate **Spawning Frequency (S)**, i.e. the proportion of females spawning per day, was estimated from the incidence of postovulatory follicles 1 and 2 day old in the gonads of mature females (Hunter and Macewicz, 1985) (the number of females with Day-0 POF was corrected by the average number of females with Day-1 or Day-2 POF).

Mean and variance of the adult parameters are estimated following equations for cluster sampling (as suggested by Picquelle and Stauffer, 1985):

Equation 3
$$Y = \frac{\sum_{i=1}^{n} M_i \, y_i}{\sum_{i=1}^{n} M_i}$$

Equation 4
$$Var(Y) = \frac{\sum_{i=1}^{n} M_i^{2} \, (y_i - Y)^2}{\overline{M}^{2} \, n \, (n - 1)}$$

Where,

Y_i is an estimate of whatever adult parameter from sample *i* and M_i is the size of the cluster corresponding to sample *i*. occasionally a station produced a very small catch, resulting in a small sub-sample size. To reflect the actual size of the station and its lower reliability, small samples were given less weight in the estimate. For the estimation of W, F and S, a weighting factor was used, which equalled to 1 when the number of mature females in station *i* (M_i) was 20 or greater and it equalled to $M_i/20$ otherwise. In the case of R when the total weight of the sample was less than 800 g then the weighting factor was equal to total weight of the sample divided by 800 g, otherwise it was set equal to 1. In summary for the estimation of the parameters of the Daily Fecundity we are using a threshold-weighting factor (TWF) under the assumption of homogeneous fecundity parameters within each stratum.

The Spawning–Stock Biomass is estimates as the ratio between the total egg production (P_{tot}) and Daily Fecundity (DF).

B3.2.6 Egg abundance estimates 1999–2012

Table B3.2.6.1. Sardine egg abundances in the Bay of Biscay from 1999 to 2012.

Ab.tot.Sp is the sum along all the stations of the sardine eggs in each station multiplied by the area each station represents. Pos.area is the positive area for sardine; tot area is the total area surveyed; %pos area is the percentage the positive area represents in relation to the total area and Ptot is the total egg production.

Year	Ab.tot_Sp	pos area	tot area	% pos area	Ab.tot/pos.area	Ptot(egg/day)
1999	**1.3E+12**	26,679	59,193	45	5.0E+07	7.8E+11
2000	**5.0E+12**	40,139	52,212	77	1.2E+08	
2001	**9.2E+11**	14,547	51,629	28	6.3E+07	
2002	**8.3E+12**	39,112	50,951	77	2.1E+08	4.4.E+12
2003	**2.8E+12**	22,878	47,927	48	1.2E+08	
2004	**9.2E+12**	37,289	49,446	75	2.5E+08	
2005	**1.1E+13**	38,979	50,202	78	2.8E+08	
2006	**3.8E+12**	23,376	45,413	51	1.6E+08	
2007	**2.3E+12**	16,710	45,499	37	1.4E+08	
2008	**9.4E+12**	20,235	46,501	44	4.6E+08	6.0.E+12
2009	**7.53E+12**	34,746	60,733	57	2.2E+08	
2010	**1.06.E+13**	36,361	61,940	59	2.9E+08	
2011	**4.50.E+12**	22,851	98,405	23	2.0E+08	available
2012	**5.68E+12**	20,054	80,381	25	2.8E+08	

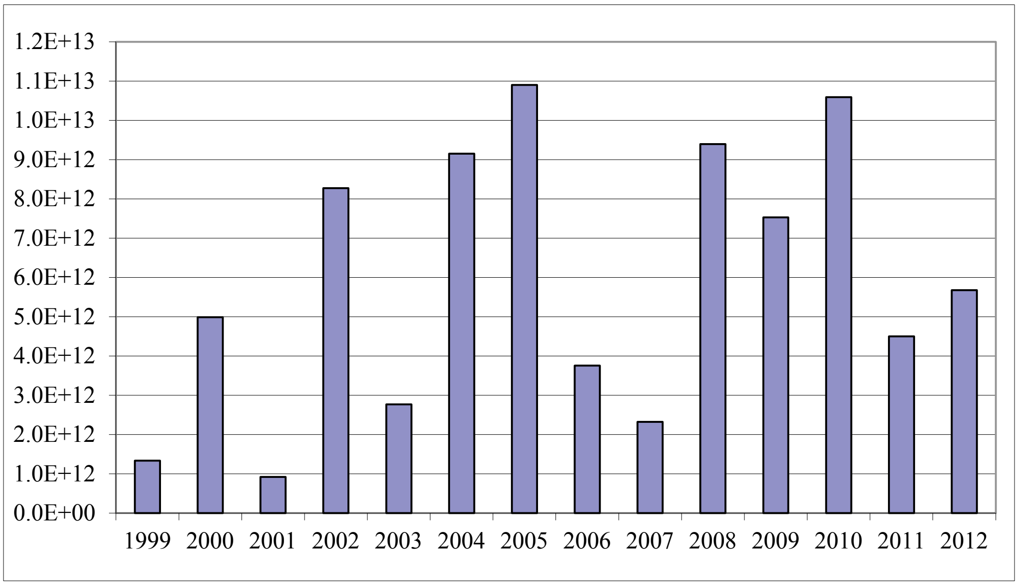
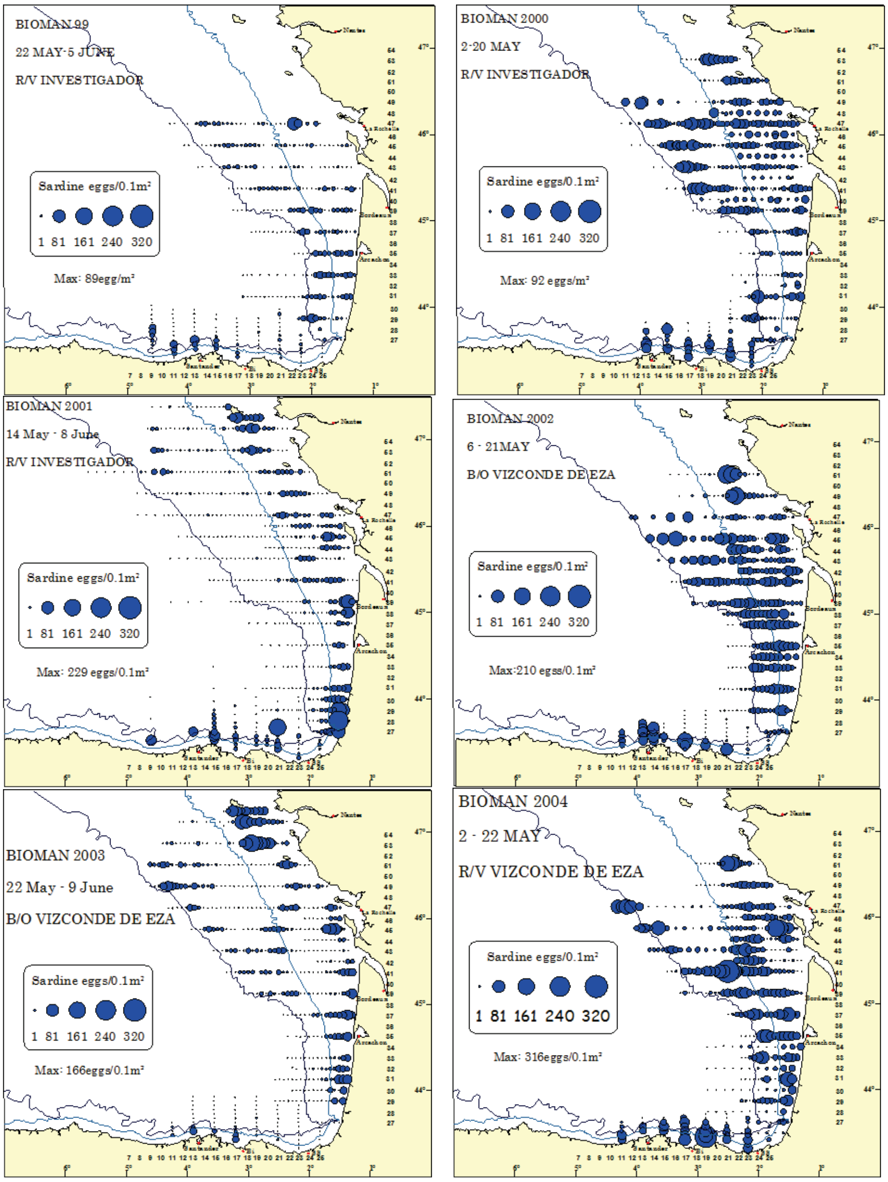
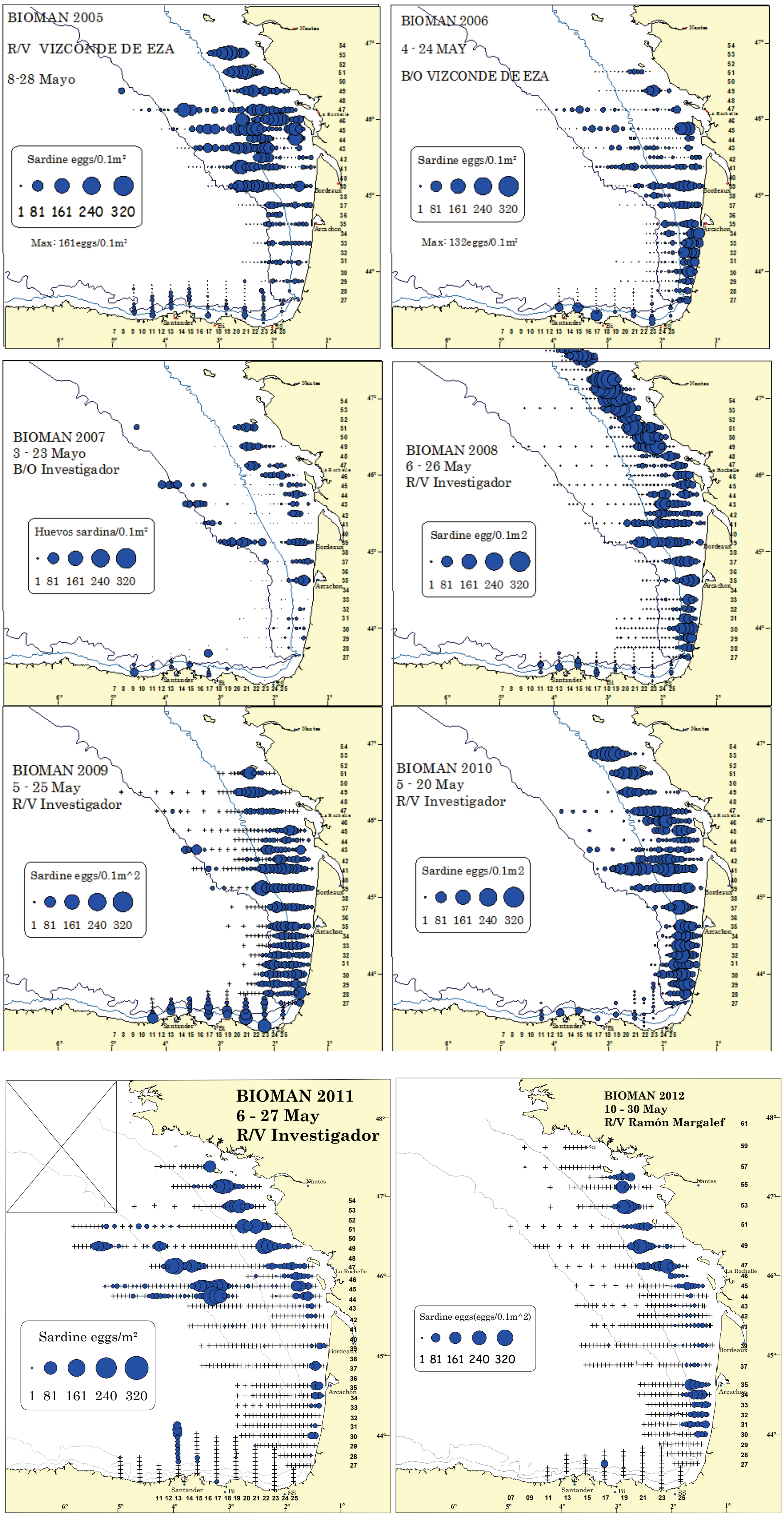


Figure B3.2.6.1. Total sardine egg abundance estimates from 1999 to 2012 in the Bay of Biscay.

B.3.2.7 Historical series DEPM and acoustic surveys




BIOMAN 2005
R/V VIZCONDE DE EZA
8-28 Mayo
Sardine eggs/0.1m²
1 81 161 240 320
Max: 161eggs/0.1m²
BIOMAN 2006
4 - 24 MAY
B/O VIZCONDE DE EZA
Sardine eggs/0.1m²
1 81 161 240 320
Max: 132eggs/0.1m²
BIOMAN 2007
3 - 23 Mayo
B/O Investigador
Huevos sardina/0.1m²
1 81 161 240 320
BIOMAN 2008
6 - 26 May
R/V Investigador
Sardine egg/0.1m2
1 81 161 240 320
BIOMAN 2009
5 - 25 May
R/V Investigador
Sardine eggs/0.1m^2
1 81 161 240 320
BIOMAN 2010
5 - 20 May
R/V Investigador
Sardine eggs/0.1m2
1 81 161 240 320
BIOMAN 2011
6 - 27 May
R/V Investigador
Sardine eggs/m²
1 81 161 240 320
BIOMAN 2012
10 - 30 May
R/V Ramón Margalef
Sardine eggs(eggs/0.1m^2)
1 81 161 240 320

B. 3.3 Sardine Daily Egg Production Method (SAREVA Survey) in the inner of the Bay of Biscay

B.3.3.1 Introduction

The Daily Egg Production Method (DEPM) is a well-established methodology to assess the spawning biomass (SSB) of fish species with indeterminate fecundity. The Sardine DEPM is based on the equation (Picquelle and Stauffer, 1985; Lasker, 1985):

$$SSB = \frac{Area^{+} * P0 * W}{F * S * R}$$

Where

P_0: Daily egg production (eggs/m^2/day)

Area $^+$: Spawning area

W: Average weight of mature females in grams

F: Batch fecundity, number of eggs spawned per mature female per batch

S: Spawning fraction, fraction of mature females spawning per day

R: Sex Ratio is the fraction of the mature population that are females by weight.

The Daily Egg Production Method (DEPM) for sardine has been applied by Instituto Español de Oceanografía (IEO) to estimate the spawning–stock biomass of the North Atlanto-Iberian sardine stock since 1988 (García *et al*., 1992) and then repeated in 1990, 1997, 1999, 2002, 2005, 2008 and 2011. From 2000 onwards the surveys have been planned and conducted within the framework of ICES, on a triennial basis. Spring surveys for the application of the DEPM, consisting of ichthyoplankton, adults and hydrographic sampling, and since 1997 the sampling area was extended in order to reach the 45 degrees latitude North, covering the region from the northwestern (border Minho River), north Iberian Peninsula (north Spanish Atlantic and Cantabrian waters, ICES Division IXa North and VIIIc) and the inner part of the Bay of Biscay (from 42 ºN to 45°N, ICES Division VIIIb).

This section provides a description of the sampling, laboratory analysis and estimation procedures used to obtain the sardine spawning–stock biomass estimate for the application of DEPM conducted by IEO from 1997 to present in the inner of the Bay of Biscay (ICES Division VIIIb). Since 2002 extra effort was put in place in order to standardize methodologies for surveying, laboratorial and data analyses. These objectives were possible due to methodological developments and effective coordination undertaken first by the SGSBSA (ICES 2002–2004) and later by the WGACEGG (Stratoudakis *et al*., 2004; Stratoudakis *et al*., 2006; ICES, 2009; ICES, 2010; ICES, 2011).

Estimations for area delimitation (surveyed & spawning), egg ageing, mortality and model fitting for egg production (P_0) are presented. Results from adults fishing sampling are showed and parameters from the mature fraction of the population (mean females weight, sex ratio, batch fecundity and spawning fraction) are calculated. Estimates were based on procedures and software adapted and developed during the WKRESTIM 2009 and modifications carried out subsequently for the revision of the sardine DEPM historical series (1988–2011) in Divisions IXa and VIIIc.

Sardine DEPM estimates in the inner of the Bay of Biscay (the inner part of Divisions VIIIb until 45˚N) from 1997 until 2011, were presented in ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX

(WGACEGG) last November of 2012, in order to be considered as a contribution for the ICES WKPELA 2013 meeting for sardine in Subarea VII and Divisions VIIIa, b, d.

B.3.3.2 Methodology

B.3.3.2.1 Surveying

From 1997, six DEPM surveys were carried out by IEO (1997, 1999, 2002, 2005, 2008 and 2011). The Spanish surveys were undertaken using two vessels, RV Cornide de Saavedra for plankton sampling mainly and RV Thalassa to carry out the fishing hauls (in 2008 and 2011 some fishing hauls were carried out on RV Cornide de Saavedra). The surveys were designed to obtain en adequate spatial and temporal coverage during the spawning peak of sardine in the area. Due to the bad weather, in 2005 was not possible to complete the plankton sampling coverage, so no data for this year is presented in this work.

Plankton sampling

The main egg sampler for the DEPM is the PairoVET net that collects eggs through the water column at point stations. The PairoVET sampler (=double CalVET) includes two nets (Ø 25cm) with 150 µm mesh size; sampling covered the water column from bottom, or 100 m (beyond the 100 isobath) depth, to the surface. Vertical plankton hauls were carried out following a pre-defined grid (Figure 3.3.2.1.1) of sampling stations along transects perpendicular to the coast and spaced 8 miles from 2005 onwards. The inshore limit of the transects is determined by bottom depth (as close to shore as possible) while the offshore extension was decided adaptively, based on the presence of eggs and covering the extension of the platform to the 200 m isobath.

From 2002, the Continuous Underway Fish Egg Sampler (CUFES) was used as an auxiliary egg sampler, helping in defining the offshore extension of the transects and to modify adaptively the intensity of CalVET sampling. The outer limit of a transect was reached when two consecutive CUFES samples were negative beyond the 200 m depth.

From 1997 to 2005, a CTD (Sea Bird-25) profile (Temperature and Salinity) was carried out in each CalVET station. From 2008 to 2011 the Sea Bird-25 was used in each transect head and in alternate stations along the transects, meanwhile a CTD (Sea Bird-37) was coupled to the CalVET sampler. General Oceanics Flowmeters were used to record the towing length and estimate the sampled water volume (assuming a filtration efficiency of 100%).

After hauling, nets are washed from the outside with seawater under pressure and plankton samples from the two nets are preserved in formalin at 4% in distilled water and the two samples from each net stored in separate containers. Samples for one net are then sorted, and sardine, anchovy and other eggs are identified and counted. The total numbers of eggs from both plankton samplers, CalVET and CUFES, were counted onboard in order to obtain a preliminary data of sardine egg abundance and distribution.

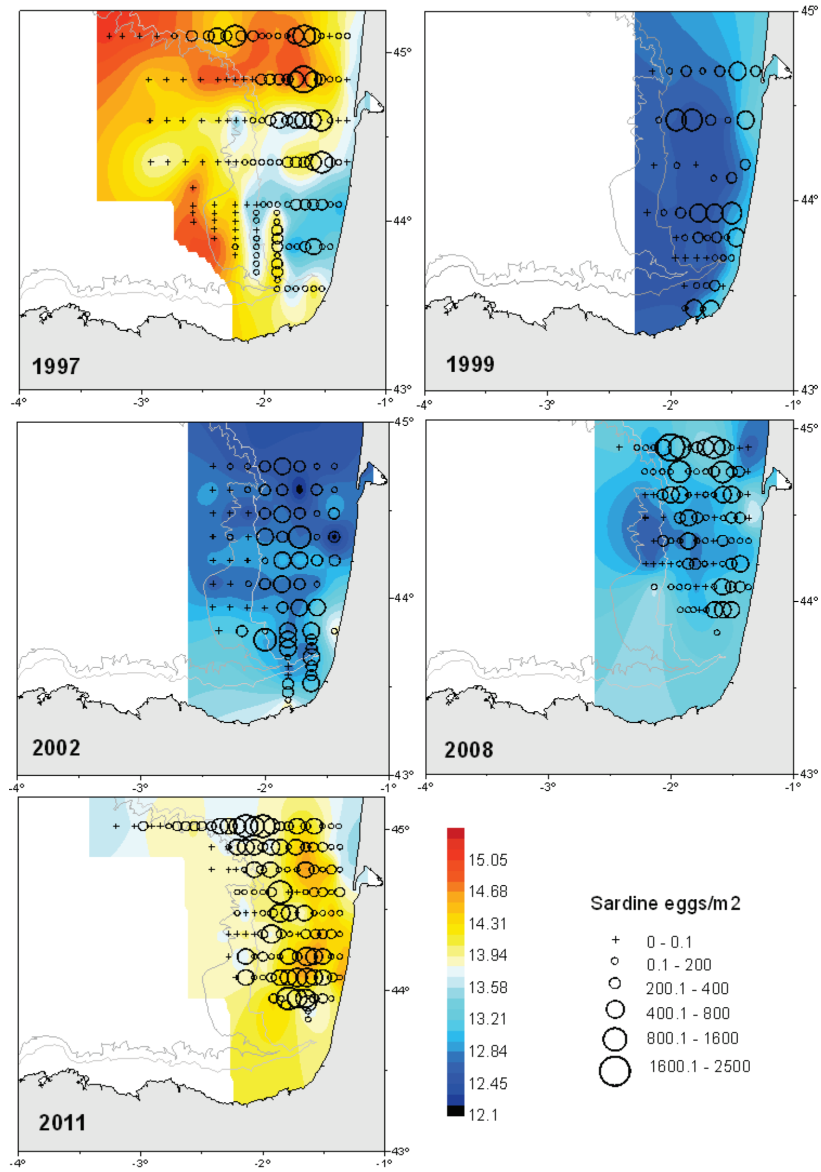


Figure 3.3.2.1.1. Sardine DEPM IEO surveys in the inner of the Bay of Biscay. Sardine egg distribution (eggs/m² from PairoVET sampler) and SST (ºC) by year.

Adult fish surveying

Fishing hauls were conducted by pelagic trawling following sardine schools detection by the echosounder (for RV Thalassa). The number of samples and its spatial distribution was organized to ensure good and homogeneous coverage of the survey area (Figure 3.3.2.1.2) in order to obtain a representation of the sardine population.

Onboard the RV, and for each haul, a minimum of 60 sardines were randomly selected and biologically sampled. These could also be complemented by additional fish in order to achieve a minimum of 30 females per haul for histology, and/or to obtain extra hydrated females for the fecundity estimations. The biological sampling was always carried out in fresh material, and ovaries were immediately collected and preserved in a formaldehyde buffered solution (4% diluted in distilled water) for posterior histological processing and analysis at the laboratory. Moreover, otoliths were extracted on board to obtain the age composition per sample in the laboratory.

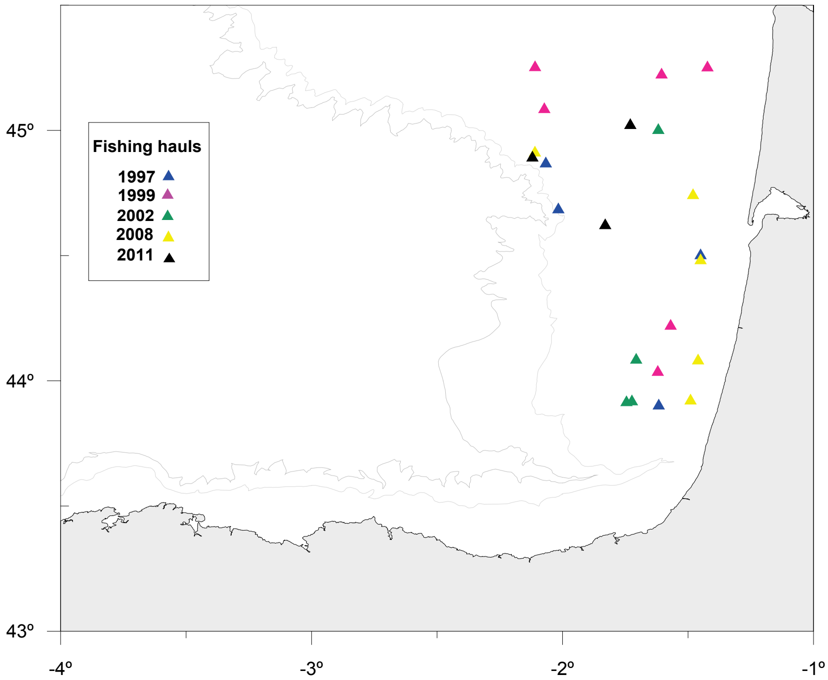


Figure 3.3.2.1.2. Sardine DEPM IEO surveys in the inner of the Bay of Biscay. Spatial distribution of the positive fishing hauls by year.

B.3.3.2.2. Laboratorial analysis

Plankton samples

In the laboratory, all sardine eggs were sorted from PairoVET samples. The eggs from the vertical hauls (one net) were all counted and staged according to the eleven stages of development classification (adapted from Gamulin and Hure, 1955). Samples for the second net are used for plankton biomass quantification.

Adult fish samples

The preserved ovaries were weighted in laboratory and the obtained weights corrected by a conversion factor (between fresh and formaldehyde fixed material) established previously. These ovaries were processed for histology, first, they were embedded in resin (paraffin before 2005), the histological sections were stained with haematoxylin and eosin, and then the slides examined and scored for their maturity state, POF presence and age assignment (Hunter and Macewicz, 1985; Pérez *et al.*, 1992a; Ganias *et al.*, 2007). Prior to fecundity estimation, hydrated ovaries were also processed histologically in order to check for POF presence and thus avoid underestimating fecundity (Pérez *et al.*, 1992b). The individual batch fecundity was then measured, by means of the gravimetric method applied to the hydrated oocytes, on 1–3 whole mount subsamples per ovary, weighting on average 50–150 mg (Hunter *et al.*, 1985).

B.3.3.2.3 Data analysis

Databases with date, time, position, bottom depth and other variables registered during the sampling on board and in the laboratory, were merged in a common standardised dataset (eggs and adults data separately) and include all surveys undertaken in the period from 1997 to 2011. The dataset for eggs and adults include minor corrections (e.g. wrong geographical coordinates, duplicated points, ovary and total weights data, etc.), that were observed as mistakes in a first exploration data. All estimations and statistical analysis were performed using the R software (www.r-projet.org).

Egg data

Calculations for area delimitation, egg ageing and model fitting for egg production (P_0) estimation were carried out using the R packages (*geofun, eggsplore and shachar*) available within the open source project *ichthyoanalysis* (http://sourceforge.net/projects/ichthyoanalysis). Some routines of the R packages used were updated since the 2008 versions.

The coastline and depth contour were imported from the GEBCO coastline, transformed into spatial objects to be used with the statistical software R. The limits of the survey area (sampled) and positive area (area with eggs), both offshore and coastal, were estimated using the library geofun, which mainly use the spatial analysis functionality provided by spatstat. To define the precision of the poligons to be selected, a 600x600 resolution was used in the spatstat function (spatstat.options(npixel=c(600,600)).

To find the geographical limits of sampled and positive areas the findlimits.fun function was used. The procedure includes an automated routine using neighbourhood distance, in km, between stations (minimum distance in ratio represented by each station). The routine thus generates circles around each sampling point and uses the intercepts between circles to define the sampling area. To estimate the limits of the sampled area, the argument dist was set to 15 km (findlimits.fun (data, dist = 15, plot = "limits")) and all the sampled stations were used in the analysis.

The limits of the spawning area (positive area) were obtained using only those stations with eggs, the diameter of the circles was the same referred above (15 km) allowing embedment of negative stations fully surrounded by positive stations. After this initial delimitation of positive area, the function erode.owin (with diameter = 10 km) was used to reduce the external limits of the positive area, in order to limit the amount of negative (offshore) stations included in the positive area. With this trimming only the negative stations on the borders are excluded from the positive areas. The stations within that domain are flagged as positive and thereafter used in the analyses. Both the survey and total areas were afterwards corrected to avoid extrapolation to the coast, by computing the intercept between the areas estimated as above and the area delimited by the coastline.

To avoid high and low extremes values detected in the area represented by each sampled station, the parameter "area.range" was forced to the minimum and maximum values of 25 and 175 respectively (the extreme values usually occur on the borders of the survey area and therefore do not affect the estimation of the positive area). The area.range parameter was included in the estimate.sea.area function during the present analyses to avoid over estimation of the areas on the borders of the survey limits. The range 25–175 was selected to be a mean interval suitable for all the surveys, according to the distance between transect and stations (that varied in the initial years; from 2002 onwards it was fixed to be 8 nm between transects and 3 or 6 nm between stations, along transects).

The area represented by each station within the survey limits is estimated by a dirichlet tessellation of the survey stations, using the survey limits as estimated above. The positive area is the sum of the areas of the individual stations included in the positive area (including also the negative stations embed in the positive area).

The model of egg development with temperature was derived from the incubation experiment data available within the *sardata* R library. Egg ageing was achieved by a multinomial Bayesian approach described by Bernal *et al*. (2008) and using *in situ* SST.

depm.control function from *egg* package, controls some constants for DEPM as the assumption of spawning peak, the proportion of eggs that must still be unhatched (i.e. not transformed to larvae) at "2*sig" past the last cohort mean age (how.complete) and the distribution of the daily spawning cycle. For the present analyses the distribution of the daily spawning cycle was assumed as a normal (Gaussian) distribution, with a peak at 21:00 h GMT and a standard deviation of 3 h. (spawning period from 21-6 h to 21+6 hours). It is assumed that 0 time is at midnight and days are 24 hours long.

The upper age cutting limit was determined using a maximum age for the entire area considered and it is not dependent on the individual stations (upper.age=F). Older cohorts are dropped if their mean age plus 2* st-dev hours is over the critical age at which less than 5% of the eggs are expected to be still unhatched (how.complete=95%). The lower age cutting excluded the first cohort of stations in which the sampling time is included within the daily spawning period (lower.age=T).

The exponential model: $E[P] = P0\ e^{-Z\ age}$ was fitted as a Generalized Linear Model (GLM) with negative binomial distribution and log link. For 1999 survey a model without mortality was applied since an estimate for mortality led to non-coherent mortality. Weights proportional to the relative area represented by each station (estimated using the dirichlet tessellation and divided by the mean area represented by a station) were used to account for increased sampling in areas of expected high egg densities.

Finally, the total egg production is calculated multiplying the daily egg production ratio (eggs per m^2 and day) by the positive area (in m^2).

$$Ptot = P0 * A+$$

Fish data

The adult parameters estimated for each fishing haul considered only the mature fraction of the population (determined by the fish macroscopic maturity data) and was based on the biological data collected from surveys. For the present estimations, a minimum sample criterion (n = 30) was introduced: a few hauls containing less than 30 fish sampled were excluded from the mean and variance calculations.

Before the estimation of the mean female weight per haul (W), the individual total weight (Wt) of the hydrated females was corrected by a linear regression between the total weight of non-hydrated females and their corresponding gonad-free weight (Wnov). The sex ratio (R) in weight per haul was obtained as the quotient between the total weight of females on the total weight of males and females.

The fraction of females spawning per day (S) was determined, for each haul, as the average number of females with Day-1 or Day-2 POF, divided by the total number of mature females (the number of females with Day-0 POF was corrected by the average number of females with Day-1 or Day-2 POF, and the hydrated females were not included).

In 1999 no histology samples were available to estimate spawning fraction (S) and a non-parametric bootstrap approach was performed using mean spawning fraction by each haul obtained along the all series and considering a single haul as the basic sampling unit. Hauls were resampling with replacement from the original dataset, leading to a new, artificial sample that was then used to estimate S parameter. By repeating this procedure an adequate number of times (1000 in this application), we obtained an empirical probability distribution for the S parameter.

The expected individual batch fecundity (Fexp) for all mature females (hydrated and non-hydrated) was estimated by modelling the individual batch fecundity observed (Fobs) in the sampled hydrated females and their gonad-free weight (Wnov) by a GLM (with a negative binomial error distribution and an identity link). In 1999, 2002 and 2008, no hydrated o very few hydrated females were collected off the Inner of the Bay of Biscay (no one in 1999 and 2002, and n = 3 in 2008). For these years, F was modelled polling data from the inner Bay of Biscay and North Spanish coast, but F estimates were nevertheless calculated for the two areas separately.

The mean and variance of the adult parameters for all the samples collected was then obtained using the methodology from Picquelle and Stauffer, 1985 (weighted means and variances).

Spawning-stock biomass (SSB)

Spawning–stock biomass (SSB) is obtained based on the equation proposed by Picquelle and Stauffer (1985):

$$SSB = \frac{Area^{+} * P0 * W}{F * S * R}$$

For the calculation of the coefficient of variation, variance is estimated using the Delta method (Seber, 1982), in which the squared CV of the product of several parameters is equal to the sum of their squared CVs:

$$CV(B)^2 = CV(P)^2 + CV(W)^2 + CV(R)^2 + CV(F)^2 + CV(S)^2.$$

B.3.3.3 Results

Eggs

Total transects and PairoVET stations that were sampled along the years are summarised on Table 3.3.3.1. In 1997 and 2011 the number of samples performed was higher than others years and 1999 was the year with less stations sampled. The percentage of stations with sardine eggs was higher than 63% for all years and has been increasing from the first survey (1997) until the last one (2011), reaching 85% in 2011. In total 6667 were sorted, staged and counted for the vertical tows in the area studied, of which 2764 were caught in 2011, around 1100 in 1997, 2002 and 2008, and 586 in 1999. The highest egg abundances per haul were 2332.1 (eggs/m^2) and 2321.7 (eggs/m^2) reached in 2008 and 2011 respectively. The lowest egg abundance per haul was 1185.4 (eggs/m^2) in 1999 and with values ranged from 1185.5 to 1669.6 (eggs/m^2) for 2002 and 1997 respectively.

Table 3.3.3.1. Sardine DEPM IEO surveys in the inner of the Bay of Biscay. General sampling for eggs.

SURVEY EGGS	1997	1999	2002	2008	2011
R/V	Cornide de Saavedra				
Date	27/03–02/04	03/04–05/04	06/04–12/04	20/04–24/04	09/04–15/04
Transects	12	11	10	8	10
PairoVET stations	140	48	75	97	134
Positive stations	89 (63.6)	37 (77.1)	55 (73.3)	74 (76.3)	114 (85.1)
Tot. Eggs	1123	586	1090	1104	2764
Max eggs/m^2	1669.6	1185.4	1220.1	2332.1	2321.7
Temp (°C) min/mean/max	12.8/14.1/15.3	12.5/12.7/13.3	12.1/12.9/13.9	12.6/13.1/13.9	13/14/14.7
CUFES stations	-	-	130	95	137
Positive CUFES stat.	-	-	88(67.7)	84 (88.4)	124 (90.5)
Tot. Eggs CUFES	-	-	7108	13837	39798
Max eggs/m^3	-	-	83.6	215.5	97.3

For all the surveys, 99.2% of the sardine eggs have been classified into eleven stages according to the degree of embryonic development. It has been found sardine eggs in all the described stages (except stage I in 1999 and 2002). The most abundant development stages were II, V and VI. Very few eggs of stage I and XI (right after and before the spawning and hatching respectively) were found along the series.

Sardine egg distribution, obtained from the PairoVET sampler, for the whole area is presented in Figure 3.3.2.1.1. Almost the entire shelf (from coast to slope) was occupied by sardine eggs. For some years (1997, 2008 and 2011), two areas of spots with higher density occurred along the coast and offshore, namely in waters along the end of the continental slope (200 m depth), meanwhile some zones of weaker density in the distribution were observed between both, coast and offshore waters.

The oceanographic setting during the period of the surveys for the region was showed in Figure 3.3.2.1.1 and Table 3.3.3.1. Minimum, mean and maximum measured SST ranged from 12.1 to 15.3°C. The highest temperature values were observed in 1997 and 2011; meanwhile the lowest one was registered in 2002.

The estimates of both surveyed and spawning area, mortality, daily egg production and total egg production are given in Table 3.3.3.2.

The largest area sampled was reached in 1997, covering a total of 20 149 km^2 (Table 3.3.3.2), while the smallest one was 6793 km^2 in 1999. The spawning area was quite similar in 1997 and 2011 (12 755 km^2 and 12 400 km^2 respectively), smaller in 2002 and 2008 (9154 km^2 and 8167 km^2) and the lowest value was obtained in 1999 (5724 km2). The percentage of spawning area over the sampling area was all the years greater than 60%, reaching the 80% in 1999, 2008 and 2011.

Table 3.3.3.2. Sardine DEPM IEO surveys in the inner of the Bay of Biscay. Summary of the results for eggs.

PARAMETER	YEAR				
Eggs	**1997**	**1999**	**2002**	**2008**	**2011**
Survey area (Km²)	20 149	6793	11 888	10 187	14 091
Positive area (Km²) (%)	12 755(63)	5724(84)	9154(77)	8167(80)	12 400(88)
Z (hour⁻¹)(CV%)	-0.012(41)	-0.006(89)	-0.022(18)	-0.019(26)	-0.018(22)
Max age (hours)	66.8	81.6	81.6	78.6	68.8
Daily mortality rate (%)	25.3	13.7	41.7	37.3	35.6
P0 (eggs/m²/day)(CV%)	136.6(20)	78.7(13)	182.3(19)	171.4(23)	219.1(16)
P0 tot (eggs/day) ($x10^{12}$) (CV%)	1.74(20)	0.45(13)	1.67(18)	1.4(23)	2.72(16)

Mortality values for the period between 2002 and 2011 are much higher than for the 1997 values. Mortality calculated for each one of the years surveyed (except 1999) shows negative and significantly different from zero values and was considered acceptable for egg production estimation. For 1999 survey a model without mortality was applied since an estimate for mortality led to non-coherent (positive) mortality.

Daily egg production per m^2 ($eggs/m^2/day$) in 2011 (219) is the highest in the series, meanwhile the lowest (78.7) corresponds to 1999. Total egg production (eggs/day) estimated by year is shown in Figure 3.3.3.1 and ranged between $0.45x10^{12}$ (1999) to $2.72x10^{12}$ (2011). Total egg production in 2011 was almost two times higher than 1997, 2002 and 2008 estimated.

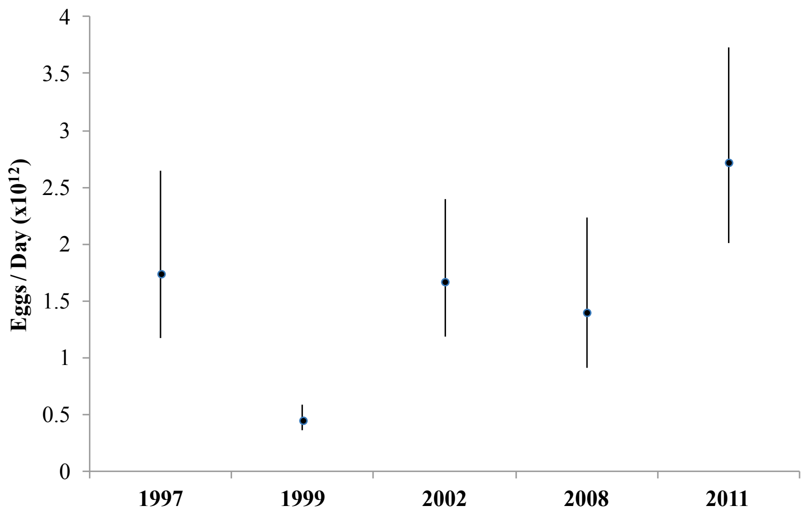


Figure 3.3.3.1. Sardine DEPM IEO surveys in the inner of the Bay of Biscay. Time-series of total egg production (eggs/day x 10^{12}) estimates. Vertical lines indicate confidence intervals.

Adults

On the whole DEPM series, 22 fishing hauls which caught sardines were performed during the surveys using pelagic trawling (Figure 3.3.2.1.2). The fishing effort and its spatial distribution were made to guarantee good and homogeneous level of sampling for the survey area.

In total, almost 1759 sardines were sampled (Table 3.3.3.3) and more than 500 ovaries were collected, preserved and analysed histologically. On the whole, a total of 749 otoliths were removed for age determination in 1999, 2002, 2008 and 2011. A total of 71 hydrated females were caught for batch fecundity estimation, although ovaries from hydrated females caught in 1999 (12) and 2002 (2) were not preserved for histological analysis on the laboratory and not number of oocytes was obtained to estimate batch fecundity.

Table 3.3.3.3. Sardine DEPM IEO surveys in the inner of the Bay of Biscay. General sampling for adults.

SURVEY ADULTS	1997	1999	2002	2008	2011
R/V	Thalassa	Thalassa	Thalassa	Thalassa/ Cornide de Saavedra	Cornide de Saavedra
Number positive hauls	4	6	4	5	3
Date	29/03–31/03	06/03–10/03	29/03–31/03	21/04–24/04	13/04–15/04
Time range			07:00–20:00		
Total sardine sampled	239	516	199	503	302
Total males	104	241	106	280	150
Total females (% Mature)	135 (100)	271 (98)	93 (100)	223 (100)	152 (100)
Length range (mm)	180–255	123–260	152–244	154–250	175–243
Weight range (g)	45–144	13–152	23–104	25–114	41–102
Oocyte stage ovaries	68	50	20	164	127
Hydrated females (Batch fecundity)	42	12		3	14
Females for spawning	68		20	161	124
Otoliths	NA	328	195	97	129
Ages Range		1–10	1–8	1–9	1–9

Length and age distribution of sardine is showed in Figure 3.3.3.2. Sardine shows a bimodal length distribution in 1999 and 2008, with the first mode about 15 and 17 cm respectively and the second about 21 and 20 cm. In 1999 the size range is the wider for the whole historical series, with a minimum of size measured of 12.3 cm and a maximum of 26 cm. The age structure of the sampled population is different by year, and it must be noticed that the number of individuals, especially between 1 and 3 ages were really important in all years which otholits were collected.

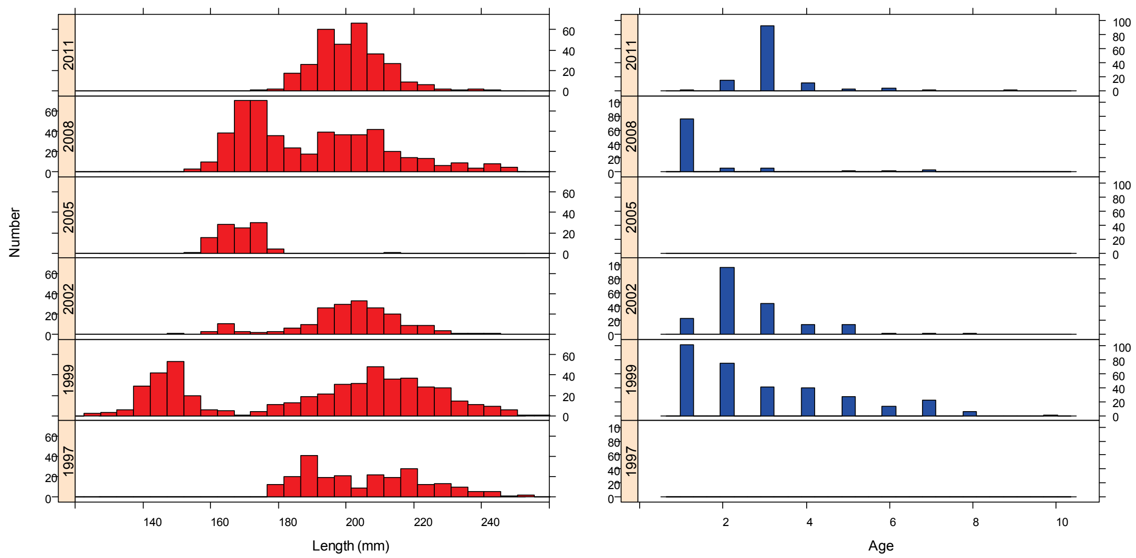


Figure 3.3.3.2. Sardine DEPM IEO surveys in the inner of the Bay of Biscay. Length (mm) and age distribution of sardine by year. No otoliths for age reading were available in 1997.

Final estimates of the mean female weight (W), batch fecundity (F), sex ratio (R), spawning frequency (S) and spawning–stock biomass (SSB) with their CVs are given in Table 3.3.3.4.

Table 3.3.3.4. Sardine DEPM IEO surveys in the inner of the Bay of Biscay. Summary of the results for eggs, adults and SSB estimates.

Parameter	Year				
Eggs	**1997**	**1999**	**2002**	**2008**	**2011**
Positive area (Km²) (%)	12 755(63)	5724(84)	9154(77)	8167(80)	12 400(88)
Z (hour⁻¹)(CV%)	-0.012(41)	-0.006(89)	-0.022(18)	-0.019(26)	-0.018(22)
P0 (eggs/m2/day)(CV%)	136.6(20)	78.7(13)	182.3(19)	171.4(23)	219.1(16)
P0 tot (eggs/day) (x10¹²) (CV%)	1.74(20)	0.45(13)	1.67(18)	1.4(23)	2.72(16)
Adults					
Female Weight (g) (CV%)	74.5(11.8)	63.6(12.7)	62.9(5.6)	55.4(11.1)	61.3(9)
Batch Fecundity (CV%)	32 269(17)	32704(45)	24577	15849(29)	30 383(4)
Sex Ratio (CV%)	0.508(8.1)	0.535(10.7)	0.492(22.9)	0.483(8.9)	0.51(19.6)
Spawning Fraction (CV%)	0.131(9.7)	0.124(15.4)	0.143	0.137(24.4)	0.066(49.2)
Spawning Biomass (tons) (CV%)	**60 332(31)**	**13 200(52)**	**60 720**	**73 942(47)**	**162 930(55)**

The minimum mean weights by haul were observed in 1999 and the maximum 1997. Mean female weight (W) was similar for 1999, 2002 and 2011(63.6, 62.9 and 61.3, respectively) and considerably higher in 1997 (74.5). Mean females weights in 2008 survey present the lowest value of the historical series (38.1). Concerning sex ratio estimates, mean values are quite homogeneous across the whole surveys.

Considering that few hydrated females (n=3) were collected in 2008 and no hydrated females were available in 1999 and 2002, the data from these three years were pooled with data from North Atlantic Spanish coast, for the modelling of batch fecundity. Mean batch fecundity estimate (F) was considerably lower (15849 number of oocytes, 286 oocytes/gr) in 2008 according to the mean female weight estimated. On the contrary the first two surveys (1997 and 1999) presented the highest estimates (32 269, 433 oocytes/gr and 32 704, 514 oocytes/gr) of the historical series, though similar to the one obtained for the 2011 (30 383, 495 oocytes/gr) survey. In particular, for 2002, although mean female weight was similar to the ones obtained during the 1999 and 2011 surveys, batch fecundity estimate was reduced to 24 577 (390 oocytes/gr) when compared to the values obtained these years.

Bootstrapped estimate of spawning fraction for 1999 was 0.124. Mean Spawning fraction estimate for 2011 survey was among the lowest (0.066) of the time-series. For the remaining surveyed years the values are generally quite high and homogeneous (between 0.124 and 0.137).

SSB estimate

The whole survey-series DEPM-based SSB estimate is showed in Table 3.3.3.4. SSB in 2011 is the highest estimate of the time-series (162 930 tons), while 1999 is among the lowest of the time-series (13 200 tons). In 1997 and 2002 estimates are comparable (60 332 and 60 720 tons respectively) and in 2008 an increase in relation to the previous surveyed years was found (73 942 tons).

The lowest and highest SSB estimates found in 1999 and 2011 respectively are related to the egg production. Egg production estimate in the 1999 survey is the lowest of the time-series, probably due to the egg survey period has not covered the amount of spawning peak activity. By the contrary the large egg production estimate in 2011 is sustained by a combination of high egg production density (in eggs per day per square meter) and large spawning area. Moreover, the contribution of the lowest spawning fraction value (0.066) estimated in 2011 on the equation applied to estimate SSB, has largely increased the SSB value.

The estimates presented from DEPM application in the inner of the Bay of Biscay, are *a priori* considered provisionally. The way to obtain batch fecundity estimates for 1999, 2002 and 2008, modelling together with data from the North Atlantic Spanish coast, prevents to consider these preliminary results as definitely ones. Moreover, to solve the unreliable egg mortality estimated in 1999 an aggregated model similar to that used by Bernal *et al.*, 2011, could be tried. All these issues require further analysis in terms of implications for the best estimation procedures and reliability of the results.

B.4. Commercial cpue

According to literature, cpue indices have been considered as not reliable indicators of abundance for small pelagic fishes (Ulltang, 1980; Csirke, 1988; Pitcher, 1995; Mackinson *et al.*, 1997). Commercial catch per unit of effort data are available at various levels of aggregation (subarea/gear/years) from official data, but these are not considered indicative of stock trends (see also information from the industry, below).

B.5. Other relevant data

Interviews with the French fishing industry operating in the Bay of Biscay highlighted a potential displacement of the stock further north. This could partly explain the increase of activity in the Celtic Sea over the last decade. According to fishermen, the main driver of the Bay of Biscay fishery is the market. Many fishers could catch more sardine as regards sardine availability, but this would not be suitable due to poor levels of prices. Thus, the industry data should not directly be put in relation to variation of sardine abundance.

C. Assessment-data and method

From the modelling point of view, the lack of sampling, survey, biological information in the English Channel and Celtic Seas in contrast to the richness of the datasets available for the Bay of Biscay does not allow the use of a single assessment method for the whole area. Therefore, for practical reasons related to the availability of data between the English Channel, Celtic Seas and Bay of Biscay, it was decided to divide this stock into two "data" regions: VIIIabd and VII.

The following indicators are considered relevant for the description of the stock in the different regions:

Subdivision VIIIabd

1) Trends in the Pelgas survey index;
2) Trends in the DEPM survey index.

Subdivision VII

3) Trends in size (age?) distribution in catches (to be built up).

D. Short-term projection

No short-term projection method is currently set for this stock.

E. Medium-term projections

No medium-term projection method is currently set for this stock.

F. Long-term projections

No long-term projection method is currently set for this stock.

G. Biological reference points

No reference points are currently set for this stock. Given the differences of availability of data between the Celtic Seas, Bay of Biscay and English Channel, any set reference should take account of this or some regional reference points should be set accordingly.

Given the current lack of assessment, advices could be based on other indicators such as successive recruitment failure. These indicators are available from the current commercial and survey datasets.

H. Other issues

While the stock is considered to spread over Celtic Seas (VIIabcfjk), Bay of Biscay (VIIIabd) and English Channel (VIIdeh), the critical lack of information in Celtic Seas and English Channel impairs the possibility of assessing this stock for the whole area.

H.1. Historical overview of previous assessment methods

2013 is the first year ICES is requested to give advice for sardine in VIIIabd and VII. In previous years, exploratory assessments using TASACS were carried out during the working group on horse mackerel, anchovy and sardine (WGHANSA). Cohort tracking analyses have also been conducted this year.

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Annex A.6 Benchmark preparation

The Benchmark for anchovy in IXa is recommended to be delayed to 2015, basically due to limited man power and to allow for the new DEPM 2014 survey to be examined by WGACEGGs in Nov2014 and to input the Benchmark.

Annex 7 Audit Reviews

Audit 3 Anchovy in the Bay of Biscay (Subarea VIII)

Date: June 2013

Auditor: Gersom Costas

General

The update assessment for the Bay of Biscay anchovy is based on a two-stage biomass-based model (BBM), described in Stock Annex.

For single stock summary sheet advice:

1) **Assessment type:** update
2) **Assessment**: analytical
3) **Forecast**: presented, though based in an undetermined Recruitment (so explicit assumption nothing is known about the next coming recruitment which usually will be the major part of the next year population and catches.
4) **Assessment model**: Bayesian two-stage biomass-based model (BBM), is tuning by two series of surveys: Daily Egg Production method and acoustic surveys in spring (using both the biomass estimates and the percetange at age 1 in the population).
5) **Data issues:** The input data entering into the assessment of the anchovy stock consist of:
    - total biomass estimated by DEPM and acoustics surveys
    - proportion of the biomass at age 1 estimated by the DEPM and acoustic surveys
    - total catch during the first period (from 1st January to 15th May)
    - total catch during the second period (from 15th May to 31st December)
    - catch at age 1 (in mass) during the first period (from 1st January to 15th May).
6) **Consistency**: strong consistency with previous assessment
7) **Stock status**: The median SSB has decreased from last year to average levels in the historical series. The estimated level of biomass in 2013 is 56 055 tonnes with confidence intervals between 36220 and 88925 t. Current level of the population is well above the biomass in 1989 (used for defining Blim). The probability of SSB in 2013 being below Blim (21 000 tonnes), is 0.
8) **Man. Plan.**: A draft management plan was proposed by the EC in 2009. This plan has not yet been formally adopted by the EU but the plan has been used in the last three years (2010-2012) for establishing the TAC for the period between 1st July and 30th June. The plan is based on a constant harvest rate (30%), and sets a TAC as a percentage of the point estimate of the SSB as as-

sessed at the start of the TAC period which runs from 1st July to 30th June, but with an upper bound on the TAC (of 33 000 t), and with a minimum TAC level (of 7 000 t) applicable at SSB estimates between 24 000 tonnes and 33 000 tonnes. It is understood that the TAC this year will again be set according to this draft plan.

General comments

The report is well structured and easy to follow. Material and analysis are well described

The management advice in June is used for establishing the TAC for the period between 1st July and 30th June.

Discrepancies in the biomass estimates from DEPM and spring acoustic surveys for 2012

In general catches in the second period are larger than in the first period and most of the catches in the first period correspond to age 1.

Pending issue of whether adopting one of the two stock assessment options outlined in WKPELA (with duly justified minor variants) or finally asking for a new benchmark to solve the pending technical issues.

Technical comments

- Section 3.2.2:
    - Text cites Figure 2.2. Where is it?
    - Text say table 2.3.1 and 2.3.2 but it should say table 3.3.1 and 3.3.2
- Section 3.2.2: No cited figure 3.3.2.4
- Section 3.3.4: where is Figure 2.3.1.1?
- The legend in Figure 3.3.2.2 insufficient, e.g what is the difference between the first and second panel; or what are the triangles on third panel showing.

Conclusions

The assessment has been performed correctly and following the stock annex.

Uncertainties are considered explicitly in the assessment. This opens for opportunities to properly evaluate risks.

Currently anchovy stock seem to be in average levels of the historical series.

Checklist for review process

General aspects

- Has the EG answered those TORs relevant to providing advice?
- Is the assessment according to the stock annex description?
- Is general ecosystem information provided and is it used in the individual stock sections.
- If a management plan has been agreed, has the plan been evaluated?

For update assessments

- Have the data been used as specified in the stock annex?
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
- Is there any **major** reason to deviate from the standard procedure for this stock?
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?

Audit of Ane-pore Anchovy in Division IXa

Date: 28/06/2013

Auditor: Andrés Uriarte

General

This is a Data limited stock: There are several indicators of stock status (from surveys) but with some discontinuities which make difficult any application of the standard procedures put forward for DLS. In addition this is a short lived species for which the bulk of the population next year is unknown at the time of providing the advice; the population and catches will be sustained of one year old recruits, which are the offspring of the spawning taking place while writing this report. Therefore, despite the good effort made by the group to outline the trends in the stock in recent years as indicated by surveys, little or none insight into 2014 (the year for which the advice is provided) can be gained from the assessment provided.

The trend assessment relies the spring (and early summer) surveys. But a major improvement of the advice could be achieved by continuing the recruitment surveys already taken place sporadically in the past (the last in 2012) so that the strength of next year class would be foreseen.

Genetics, independent trends in the fisheries and in the population abundance estimates show independent dynamics of the anchovy in the north-western part of Division IXa (western Iberian waters) from the dynamics of anchovy in Subdivision IXa South(Algarve and Cadiz). For this reason since 2010 advice is split for this two populations and fisheries.

The reading of the section could be simplified through separate sections by the two regions IXa South and reminder regions of IXa. As such the Trend of biomass indices in the whole Division IXa can be misleading.

In general there is a need of reducing text, by subtracting considerations about old observations which have been clarified afterwards. In addition all the figures are first detailed in tables, some figures could be reduced or omitted given that the data are in tables.

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM!

1) **Assessment type: update**
2) **Assessment: Trend based assessment with split analysis of the tendencies** in the SubDivision IXa South (Cadiz + Algarve), where there is a well stablished population and fishery, from the tendencies in the reminder northern parts of Division IXa (western side of Iberian Peninsula), where sporadic outburst of anchovy occur in some years.
3) **Forecast**: not presented
4) **Assessment model**: <u>qualitative analyses of survey trends</u>: There are 3 series of acoustic surveys (intermittent series) and a DEPM survey (triennial). Available Commercial CPUE is disregarded as dubious indicator of abundance tendencies.

In addition the WG has carried out the following supplementary analysis:

- Evaluation of current harvest rates in the context of Harvest rates per recruit for a range of likely catchability values of the surveys.
- Exploration of length-based reference points

5) **Data issues:** The Portuguese +Spanish series of early Spring acoustic surveys (PELAGO+PELACUS), with a gap in 2012 (for technical reasons), was resumed in 2013 and made available to the WG on due time. This is the only series covering the entire Division IXa. Other surveys restricted to the Population in SubDivision IXa are: The Spanish summer acoustic survey (ECOCADIZ), started in 2004, which will be carried out again in 2013 after a disruption for 2 years. In 2012, there was a new isolated Spanish autumn acoustic survey in Cadiz (ECOCADIZ- RECLUTAS) which was made available to the group and it was framed in the context of the past series of Portuguese November acoustic surveys (SAR, 4 surveys between 1998 and 2007 including the coverage of SubDivision IXa South). It is expected that in 2014 the Spanish DEPM triennial survey will be applied again in Cadiz (it will be its fourth application). See the series in the last table of the summary sheet.

6) **Consistency**: The recruits estimates (from ECOCADIZRECLUTAS) in 2012 and the stock biomass estimate (from PELACUS-PELAGO) in 2013 in SubDivision IXa south points to recruitment and biomass consistent with past series but below average. The anchovy in IXaNorth and Central North in its usual low valuesin 2013, after the outburst observed in 2011.

7) **Stock status**: No precautionary or MSY reference values are available for the stock. The anchovy in Cadiz seem to be below average and the outburst of anchovy biomass in IXaNorth and Central North in year 2011, has reverted to the normal low levels in those SubDivisions. Results from the qualitative assessment described in Section 4.5 suggest that the anchovy population in the Sub-division IXa South is a fluctuating population without any neat tendencies, even though it is assessed below average in 2013. In the absence of any recruitment index, there is not sufficient information as to outline what the situation in 2014 will be.

   - In addition the Analysis of Harvest Rates per recruit (similar as last year) suggest recent historical exploitation levels in IXa South are sustainable.
   - The length based reference points analysis suggest that the stock is supporting in its recent history a reasonable exploitation in IXa South, with Lmean above L(F=M) and very close to Lopt and Lc=Lmat. Nevertheless, WG members question the validity or appropriateness of these reference points for short-lived species like anchovy (with stocks and catches supported mainly by only age group and a fishery operating around spawning time).

8) **Man. Plan.**: There is no Management Plan. The fisheries are regulated by an International TAC shared by Portugal and Spain and affecting all Subarea IXa.

General comments

New information: Recruits level (age 0) in 2012 (from ECOCADIZRECLUTAS) and the stock biomass estimate in early Spring 2013 (from PELACUS-PELAGO)

Catches in 2012; at usual normal levels; Above average in Cadiz and at normal low levels in the reminder region due to the decrease after the outburst of anchovy in 2011.

No major signs of warning are pointed out for the current stock and fishery situation.

Technical comments

Section 1.1 "ACOM Advice Applicable to 2012 and 2013", makes a review of all advices since 2005. Though of interest, This is probably far more than required for this section. It could have started in 2011 or simply in 2012. This should be shortened next year.

In order to avoid space, historical catches in Table 4.2.2.1.1 could be restricted to the last 30 or 25 years, letting the others in the stock annex. As the population in SubDivision IXaS is to be separated from reminder subdivisions, subtotals at these geographic regions would be convenient for this table.

(include comments on points where the draft report contains errors, is unclear and if the assessment is done according to the stock annex)

Conclusions

The assessment has been performed correctly

This consideration is relevant and the idea also appears in the summary sheet: "There is no reason to provide a single management ad-vice for the anchovy in all the Division IXa, given that the fishery and the exploited populations are spatially separated and with independent dynamics and different genetic structure. At the contrary, it would be better to provide separate advice for the well identified population in Subdivision IXa South, from the rest of the anchovy in the Division (occupying the western waters of the Iberian peninsula: IXa North, Central-North and Central-South). This would demand a separate management of the fisheries on anchovy in these two regions of the Division IXa."

Checklist for review process

General aspects

- Has the EG answered those TORs relevant to providing advice? *Yes*
- Is the assessment according to the stock annex description? *Yes*
- Is general ecosystem information provided and is it used in the individual stock sections?: *The ecosystem information is correct, but at current stage can not be used for improving the advice.*
- If a management plan has been agreed, has the plan been evaluated? *There is no MP*

For update assessments

- Have the data been used as specified in the stock annex? *Yes*
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? *Yes and there is no forecast available.*
- Is there any **major** reason to deviate from the standard procedure for this stock? *No.*
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? *Yes, but the harvest rates analysis deserves consideration on the assessment of the current fishery exploitation levels.*

Audit of Horse Mackerel in Division IXa (Southern horse mackerel)

Date: June 2013

Auditor: Isabel Riveiro

General

- The report is well structured and easy to follow. The material and analyses are generally well described.
- No Portuguese survey in 2012.
- High uncertainty in the last recruitment (highest of the time series) estimation
- Exploitation seems to be sustainable, with low rates of fishing mortalities along the data series

For single stock summary sheet advice:

1) **Assessment type:** update assessment without 2012 tuning survey

2) **Assessment:** analytical

3) **Forecast:** presented

4) **Assessment model**: AMISH – tuning by 1 survey except 2012

5) **Data issues: In** 2012, there were no survey data available for the Portuguese area (Pt-GFS-WIBTS-Q4) and therefore assessment was performed without 2012 tuning survey (*deviation from the stock annex)*.

6) **Consistency**: Due to problems related with data availability (landings), last year assessment was not performed. During 2013 WG, data from 2011 and 2012 catches were available on time. Results of the 2013 assessment shows some retrospective pattern, probably related to the high uncertainty in last recruitment estimation

7) **Stock status**: Unknown because no reference points defined (the WG proposes $F_{35\%SPR}$=0.11 as a proxy for MSY). SSB shows a decrease in the last four years (but with wide confidence interval) and F shows a decrease in the last two years. F along the time series was close to $F_{35\%SPR}$. Exploitation levels seems to be sustainable.

8) **Man. Plan.**: None

General comments

The report is well structured and easy to follow (especially the graphics)

-section 8.2.1 is empty in the report

Technical comments

Predictions were done using MFDP software instead of *mff* function described in the Stock annex. Both predictions are deterministic, hence no uncertainty was calculated. Predictions done by using a Fsq (mean of fishing mortalities of ages 2-10 in the last two yeras), stock annex describes using catch constraint. This is because the TAC (for more species) was not fully fished the last years. Fsq results in landings that resemble the ICES estimated catches.

Conclusions

The assessment has been performed correctly and following the stock annex (except for the projections and for the last survey used in the assessment model).

Recruitment estimations for the last two years could be influenced by a change in the selection pattern caused by the increase of purse seiner catches relative to the decrease in the bottom trawls catches (targeting older individuals). This fact question the reliability of the strength of the recent year classes.

Checklist for review process

General aspects

- Has the EG answered those TORs relevant to providing advice?
- Is the assessment according to the stock annex description?
- Is general ecosystem information provided and is it used in the individual stock sections.
- If a management plan has been agreed, has the plan been evaluated?

For update assessments

- Have the data been used as specified in the stock annex?
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
- Is there any **major** reason to deviate from the standard procedure for this stock?
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?

Audit of Sardine VIIIc – IXa

Date 26/06/13

Auditor: Erwan DUHAMEL

For single stock summary sheet advice:

1) **Assessment type:** update after benchmark in 2012
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: stock synthesis 3, two surveys (DEPM and acoustic), combined Portugal and Spain. Problem that year ton attribute the coastal acoustic data (no fishing haul in coastal waters)
5) **Data issues:** described in stock annex
6) **Consistency**: Strong retrospective pattern (assessment 2012 considered close to blim but above, re-evaluate under Blim.)
7) **Stock status**: according to the last assessment, B is 40% lower Blim
8) **Man. Plan.**: No international management plan (only portuguese plan)
9) **General comments**
   i. false heading in table 7.3.2.2.1.
   ii. acoustic biomass seems to be underestimated since 2 years, but may have light influence on the model.
   iii. Contrary to the perception in last years' assessment, the 2011 recruitment is estimated to be low
   iv. Where is the figure 7.5.3.1. ?
   v. No historic concerning the fleet : increasing or decreasing number of boats ?

Technical comments

vi. Lack of final biomass and reference points on the same figure

vii. Overall trends in DEPM and acoustic surveys are contradicting

viii. Concerning the input values for 2013 and 2014 recruitment (Age0), the use of the geometric mean from 2005 to 2010 seems reasonable, according to the declining trend in the recruitment time series.

Conclusions

The assessment has been performed correctly

For the Spanish acoustic survey, the help of commercial fishermen to improve the number of identification trawls hauls, particularly in coastal waters, should be useful.

Exact stock structure is unknown. This could bias the assessment if migration in and out of the assessment area takes place (probably with bay of Biscay where Spain seems to have increasing catches).

Checklist for review process

General aspects

- Has the EG answered those TORs relevant to providing advice?
- Is the assessment according to the stock annex description?
- Is general ecosystem information provided and is it used in the individual stock sections.
- If a management plan has been agreed, has the plan been evaluated?

For update assessments

- Have the data been used as specified in the stock annex?
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
- Is there any **major** reason to deviate from the standard procedure for this stock?
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?

Audit of Sardine in Subdivisions VIIIabd and Subarea VII

Date: 30/06/2013

Auditor: Andrés Uriarte & María Santos

General

This is a Data limited stock: This stock was benchmarked at WKPELA in 2013 by ICES and meanwhile it was considered to be a single stock unit, on the basis of homogeneous genetics and connectivity of fisheries and mixing of catches.

The lack of commercial sampling, surveys and biological information in Subarea VII in contrast to the richness of the datasets on those issues available for the Bay of Biscay Subdivisions VIIIabd hampers a joint analysis for the whole area. It was decided therefore to divide this stock in two "substock": VIIIabd and VII to take account of the regional differences in terms of environment, fisheries and data availability.

There are two indicators of population abundance (from surveys) in Subdivisions VIIIabd an acoustic survey (PELGAS) and an Egg survey (BIOMAN) both carried out in may which show rather consistend tendencies.

A major improvement of the advice could be achieved by implementing a good monitoring system of the fishery (length and age sampling) and of the population (surveys) in subarea VIII.

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM!

9) **Assessment type: First time an assessment will be provided.**
10) **Assessment**: Trend based assessment
11) **Forecast**: not presented
12) **Assessment model**: Trend based assessment: For VIIIabd based on two surveys (acoustic and Egg surveys in Spring every year since 2000 (aprox) (category 3 stock). For subarea VII only catches are available (category 4 stock) (The DCAC (Depletion Catch curve Analysis) was discarded in 2012 given the lack of sufficient trends and out of range level of natural mortality assumption.
13) **Data issues:** data available as described in stock annex; the known specific issues is the lack of any sampling of the fisheries and the population in subarea VII.
14) **Consistency**: First time the assessment made, so Not applicable.
15) **Stock status**: reference points are not defined.
    a. **For VIIIabd**: Acoustic Estimates oscilating in Subdivisions VIIIabd between 100 and 600 thousand t / rather similar oscilations in the egg surveys. Catches have increase by 50% compared to 2010 or the mean of 18400 t (since 1996). Although surveys indicate about 20% decrease on average in the past two years compared to the former three years,

the 2013 acoustic biomass increase is above average and it reports the highest level of recruitment at age 1 since 2010, while the egg survey remained similar to the previous year estimate.

i. Catch curve analysis suggest F at or below M, so probably sustainable.

b. **For VII**: Since 1997 catches fluctuate around its mean of about 12000t The overal recent trend in landings in subarea VII is a decrease of catch since 2010 onwards The opportunistic nature of the fisheries and the mixing between VII and VIII makes difficult any interpretation of this decrease.

16) **Man. Plan.**: There is no Management Plan.

General comments

This was a well documented and well structure section. It was easy to follow and interpret…. Etc.

The major concern to be elucidated at the ADWGHANSA is whether a single or separate advices are provided for the two subregions.

Technical comments

(include comments on points where the draft report contains errors, is unclear and if the assessment is done according to the stock annex)

- It seems that Table 6.2.1.2 & 3 are not in the same units in spite of what their legends say.
- It seems that in Table 6.2.4.1.1: Landings are shifted a year ahead, they should be put a year earlier than what they appear.
- Units should be added to all the tables of section 6.2.4.1
- The Catch curve analysis on survey and commercial fleets is pending to be completed.

Conclusions

The assessment has been performed correctly

There is no clear warning for VIII arising from the trend analysis (and given the signal of strong YC entering). Tough there is a decreasing trend for sardine in VII, of uncertain meaning given the opportunistic nature of the fishery in that area.

The Technical issues should be addressed before ADG.

Checklist for review process

General aspects

- Has the EG answered those TORs relevant to providing advice? Yes
- Is the assessment according to the stock annex description? Yes
- Is general ecosystem information provided and is it used in the individual stock sections. Sufficient for the time being.
- If a management plan has been agreed, has the plan been evaluated? No MP

For update assessments

- Have the data been used as specified in the stock annex?
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
- Is there any **major** reason to deviate from the standard procedure for this stock?
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?

Annex 8 New stock annex for anchovy in the Bay of Biscay

After the benchmark for anchovy (WKPELA 2013), a discussion took place on the final settings of the assessment, as described in Annex 8.1.

The discussion concluded with agreement from ACOM with the new stock annex (Annex 8.2) in October 2013. This stock annex will be the basis for future assessments and differs from the basis of the 2013 assessment.

Annex 8.1 Proposal for a new stock annex for anchovy in the Bay of Biscay (subarea VIII): Summary of the work carried after WKPELA for solving the technical pending issues on anchovy assessment.

Uriarte A. (AZTI), L. Ibaibarriaga (AZTI), E. Duhamel (IFREMER) and L. Pawlowski (IFREMER), M. Santos (AZTI).

1. INTRODUCTION: PENDING ISSUES FROM WKPELA

In the ICES Benchmark Workshop on Pelagic Stocks (WKPELA; ICES 2013) the assessment method (including projections) and appropriate reference points for anchovy in the Bay of Biscay were considered. The final assessment was based on a new model, the CBBM model (Ibaibarriaga et al. 2011) which includes modelling of the selectivity at age and allows for the changes of natural mortality rates by age agreed in the group. In addition, the DEPM SSB estimate was considered as a relative index, and the JUVENA juvenile acoustic biomass was included as an index of recruitment next year.

However after WKPELA the following technical issues which deserved further consideration than devoted during the meeting appeared:

a) The setting of the variances of the observation equations concerning the Spring surveys. In the option presented in the stock annex of WKPELA (called hereafter as **VarFixed - Case 1** approach) the precision of the observation equations of biomass from the Spring (DEPM and acoustic) surveys were taken as fixed (not estimated), making use of those reported by the surveys themselves. In addition the parameters defining the precision of the age 1 proportion of the spring surveys and the catches were also fixed. After the meeting another option was tested where the variances of SSB observation equations from the surveys were split into partly fixed and estimated variances (called **VarEstimated – Case 2** from now onwards). Such alternative approach was triggered after noticing that the Pearson Residuals of the initial modelling were too large, while they largely improved allowing an additional component of variance being estimated for each survey. This alternative option (VarEstimated – Case 2) was added in **Annex 3 to the WKPELA** report and was supported by the two external reviewers. The VarEstimated alternative was not adopted because it produced a retrospective pattern rather similar to the assessment carried out until 2012, whilst the original setting of the model in WKPELA (the VarFixed) strongly reduced the retrospective pattern since year 2005.

b) The Catchability model of JUVENA acoustic recruitment index and the corresponding priors were not sufficiently discussed during WKPELA. Originally the inclusion of the JUVENA juvenile abundance index in the observation equations of the CBBM assessment model was based on a linear relationship between this index and next year recruitment (age 1 biomass at the beginning of the year). This was similar to the observation equation of the DEPM and acoustic biomass indices. The hyper-parameters of the prior distribution of the catchability of the JUVENA survey were taken equal to those of the prior distributions of the catchability of the DEPM and acoustic surveys. However after the meeting it was noticed that the sensitivity of the results to the catchability model relating the JUVENA juvenile abundance index and recruitment next year (linear or power) and to the actual hyper-parameters of the prior distribution of the parameters defining this relationship were not studied in sufficient detail due to the lack of time. Furthermore, there were indications that the power model might have been preferred over the linear catchability model. Hence the catchability model of JUVENA and associated priors were included in the list of pending issues to be further studied (ICES 2013).

2 WORK AFTER WKPELA

WKPELA could not reach a consensus on the best way to overcome these technical issues. However, more work was conducted after WKPELA in order to clarify/solve them.

2.1 Before WGHANSA

A Working Document entitled "Some pending issues from WKPELA on the assessment of Bay of Biscay anchovy" (Ibaibarriaga and Uriarte WD2013) was presented to WGHANSA (ICES 2013). This WD showed that:

Regarding the Catchability model of JUVENA: Better prior distributions were found for the parameters of the observation equation of the JUVENA index which could accommodate at the same time to both the linear and power catchability models. The power model for the JUVENA index observation equation seems to be better than the linear model in statistical terms, as it results in a more precise fitting of recruitments, with a posterior power parameter markedly different from 1 (which corresponds to the linear model). In addition, the power model for the observation equation of the JUVENA index leads to narrower probability intervals for the next year recruitment than the linear model (Figure 7 of that WD), though for both catchability models the recruitments assessed after the following spring surveys were included within the predicted recruitment distribution based on the JUVENA index.

It was therefore concluded that, for the time being, the power model and the priors proposed should be set for future assessments (though this issue could be subject to regular checking in future benchmarks).

In the rest of the document the comparisons of the CBBM outputs are based on the power catchability model of the JUVENA survey.

Regarding the setting of the variance of the Spring surveys' observations: The WD made evident that the VarFixed setting leads to lower retrospective corrections in the biomasses of recent years, but to higher corrections over all the historical series of biomasses (specially for the assessments runs before 2008) in comparison with the VarEstimated settings (**Table 1** here attached). So there were advantages and drawbacks in both model settings which deserved further understanding. This issue was discussed in WGHANSA.

2.2 During WGHANSA, June 2013

The WG adopted the Catchability Power model for JUVENA with the proposed priors in the former WD. Regarding the settings of the variance of the Spring surveys' observations the WG considered potential reasons for the retrospective patterns and put forward some additional exploratory runs to see if some alternative setting of the model could minimize both the recent and historical retrospective patterns.

Among the possible reasons for the retrospective patterns, it was perceived that the two models accommodate noise and potential trends in some of the model parameters in different ways. Parameters showing trends were: Q acoustic (both models) Q DEPM (Varfixed model) and selectivities at age 1 of the first half of the year and partly of the second half of the year (both models).

In the variances Fixed model (Case 1) it was noted that the reported CV of the acoustic surveys were decreasing with time and hence it was perhaps anchoring more heavily the recent SSB estimates compared to the past, but due to the upward rescaling of the catchability of the surveys, the distant past was being revised downwards. On the other hand the Variance Estimated model (Case 2) by allowing an additional component of variances absorbed gradually the noise appearing in the data and reassessed the recent past according to the new information being added, so it changed somehow more strongly the recent past.

Several potential solutions were put forward to find an intermediate retrospective performance such as: (a) Setting a minimum CV for the surveys and take the CV of surveys as reported just in case being above the minimum CV, else take the minimum CV; (b) Fixing the CV of surveys between benchmarks; (c) Fixing catchabilities of surveys for periods of years (e.g. between benchmarks); (d) Going for an assessment addressing gradual/abrupt changes in catchability of surveys.

The WG agreed to test the following two alternative options:

A- The variances of SSB observation equations from the surveys were split into two components (observation error plus residual error as in Case 2), but with both components beingfixed (not estimated). This was named as Case 3.

B- Fixing the catchability of surveys unchanged for several years.

In addition the WG members wanted to see the performance of the different cases with data until June 2013, i.e. after addition of the available new inputs for the assessment from 2013, and thereby letting behind in the past the strong discrepancies in SSB point estimates from the Spring surveys in 2012.

And finally the working group wanted to check the reliability/performance of the projections of SSB (*Y*+1) in the December assessments of year ***Y***, achieved through the inclusion of JUVENA survey, compared to the actual estimates of such SSB(*Y*+1) immediately after the following Spring surveys in year Y+1 and versus the most recent assessment of those biomasses from the June 2013 assessment.**2.3. After WGHANSA until July 8 2013**: The proposed A and B exercises along with the requested comparison of the retrospective patterns and performance of projections were carried out right after WGHANSA.

A WD of Ibaibarriaga (annexed here), entitled "Summary of the analysis regarding pending issues for Bay of Biscay anchovy from WKPELA"[1] showed the results of carrying out the exercise A, and the latest assessments up to 2013.

First the WD confirmed that the pattern of residuals in cases 1 and 2 remained unchanged after adding the latest input data. In addition the trends of some parameters, already observed in WKPELA outputs, remained also unchanged.

The exercise A (Case 3) was run by adding a fixed component of variance equivalent to about 25% CV; it showed that this setting did not reduce the retrospective pattern of the assessment. **As such the Case 3 approach was discarded.**

This work also showed that Trends in SSB are similar for BBM (former stock annex) and CBBM Cases 1-3 (new models). BBM gives wider intervals, especially in years in which some of the surveys are missing or when the surveys disagree. The additional information coming from the catch at age data and/or JUVENA in CBBM seems to improve the inference in these cases. See an example in **Figure 1**.

The performance of the December assessment when estimating next year recruitment (based mainly on the last JUVENA survey) is similar in all the cases. The probability intervals are much narrower in the June assessment, when more information is available. The probability intervals of the JUVENA based recruitment assessment contained always the recruitment as assessed in June 2013 (figures 19 and 22 of that WD).

In addition, regarding the performance of the December assessment in terms of projections of next year biomass (i.e. combination of recruitment plus survivors estimates) it was found again that in all cases the expected (forecasted) biomass for the next Spring contained the final assessment of biomass of those years as obtained from the June 2013 assessment and as assessed in the following year (**Figure 2**). However it terms of median projected SSB estimates the performance since 2008 onwards of Case 1 model (VarFixed) was poorer than that of Case 2 (Figure 2 upper panels), because the median projected biomass for 2010 and 2011 are left outside the range of biomasses from the latest assessment estimates of those years (Figure 2 bottom panels). Certainly the performance of the Biomass projections compared with the latest assessment or with the next year assessments were visually better for the Case 2 than for the Case 1. This is quantified as a retrospective pattern of projections in **Table 2**, where it is shown that these are smaller for case 2 than for case 1.

Regarding exercise B, it was found that it did not improve the retrospective pattern in comparison with case 2, so it was discarded as well (figure 3) because of being a simplification of the former case without providing any improvement. Aiming to deal with survey catchability shifts in time, an additional exercise was carried out by L. Ibaibarriaga (with the BBM model) in which Catchability of the acoustic survey was estimated independently for the periods earlier and later than 2002. The results of this exercise (not shown) did not improve the retrospective pattern of the BBM either; therefore it is not evident that this approach would solve the retrospective pattern.

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[1] The assessment from June 2013 which was shown in the WD used by mistake for the cases 1-3 the old DEPM series inputs, However globally (as the DEPM is used as a relative index for which catchability is estimated) the outcome was valid though some concrete parameters might be re-scaled in comparison with outputs from WKPELA. Nevertheless the SSB series are globally correct. A final corrected output for the assessment in June 2013 is presented as a Table in this document for Case 2. All tables and figures presented in this letter are made with the correct inputs and outputs.

After the examination of these exercises, the subgroup considered that the retrospective pattern did not have any simple solution and there were several potential explanations which would require a longer analysis, among them:

- Changing catchability of one or the two surveys: A shift in the catchability of surveys is observed in all the model settings essayed so far (Cases 1 to 3) and it is a likely explanation of the historical retrospective pattern observed for Case 1. It was found that fixing the catchability of surveys did not remove the recent retrospective pattern (exercise B) and in addition the exercise (run for the BBM) of estimating differently the catchabilities of the acoustic surveys earlier and later than 2002 did not solve the problems. However there are other potential approaches which could be still essayed in future benchmarks as for instance other break point in the time series or allowing a gradual change in time of the catchability of one of the two surveys.
- Natural mortality by ages (i.e. more pronounced changed by ages than allowed in the new modeling?). This might be suspected from the analysis of raw data from the surveys (Uriarte and Ibaibarriaga WD to WKPELA) which suggested more bigger differences of M by ages and from the observation that the more pronounced retrospective pattern occurs around the closure of the fishery when the suitability of the natural mortality pattern should more than ever condition the match of the modeled population with the observations.
- Other options are combination of the two former issues plus some shifts in the fishery selectivity patterns. Though the later are not too pronounced along the series (and hence they should not be too influential on the retrospective), they may play some role too in combination with the other issues.

The subgroup considered that the successful reduction of the retrospective pattern of the recent past achieved by Case 1 by letting the CV reported by surveys being their only source of observation variance is a simple pragmatic approach to minimize the retrospective patterns in the short time, but it does not result from a proper treatment of the causes that generate these patterns (as it did not remove the historical retrospective pattern). Case 2 (VarEstimated) by combining the CV of surveys with an estimated additional component of variance, overcome Case 1 in terms of the statistical fitting to the observations (Pearson residuals) and in terms of performance of the projected biomasses (i.e. the projected Biomass Case 2 have smaller retrospective pattern than for Case 1). If future management would move towards setting TACs according to projections this would make Case 2 preferable over Case 1. The retrospective pattern of the recent period in Case 2 is slightly better than the former BBM model (**Table 1B**) but poorer than Case1 and the historical pattern is better (smaller) for Case 2 than for Case 1 (Table 1A). Keeping the historical retrospective pattern low has the advantage of stabilizing the inferences on historical productivity (S_R relationships) and on reference points as Blim (if taken from a past year).

For all these considerations the subgroup agreed that Case 2 would be preferable to be adopted as the assessment method of reference for the next 3-4 year until a new benchmark, even though the retrospective pattern in recent years is not sufficiently understood and will still be appearing.

Summing up some more years of observations should allow further analysis of the way to address this problem in the setting of the assessment model for this stock.

The latest assessment following the recommended model setting (Case 2 VarEstimated) which can be obtained after inclusion of the most recent information already available in June 2013 for WGHANSA meeting is available in **Table 3**.

3. CONCLUSIONS

Conclusions were achieved in two WebEx meetings on Thursday 11 and Monday 15 of July. The agreed conclusions in summary are:

- The new assessment Bayesian model for anchovy (the CBBM - Ibaibarriaga et al. 2011) along with the model setting adopted in WKPELA (with the two modifications proposed below) supposed an improvement over the former modeling (BBM) in terms of population dynamics (with resolution of the growth and natural mortality rates by age groups), of population forecasting capability by incorporation of a new input survey (JUVENA recruitment survey), and of fishery modeling by inclusion of fishery selectivity patterns on half year basis. In addition, as the modeling now estimates catchability parameters for all surveys (all are taken as relative), the new assessment model allows incorporation of the revised series of Biomass estimates from the DEPM (Santos et al, WD in WKPELA2013 report) (which could not be made in the former model because this series was taken as an absolute index of Biomass, with catchability fixed to 1).
- A power catchability model for the JUVENA recruitment index is preferable over the linear model initially proposed in the official stock annex of WKPELA (ICES 2013), because it results in a better statistical fitting of recruitments. The Subgroup recommends that the Power model and the priors proposed for the parameters of this catchability model of JUVENA (see the WD of Ibaibarriaga & Uriarte attached to WGHANSA 2013 report) are used for future assessments and therefore the stock annex is accordingly amended. This issue should be subject to regular checking and, if required, be changed in future benchmarks.
- For the setting of the Variance of the spring surveys biomass observations Case 2 (VarEstimated, corresponding to Annex 3 in WKPELA 2013 report) is preferable over the Case 1 (VarFixed - variances fixed at the reported CV of surveys, corresponding to the attached stock annex for anchovy in WKPELA 2013 Report). The reason for this is that Case 2 (VarEstimated) by combining the CV of surveys with an estimated additional component of variance, overcome Case 1 in terms of the statistical fitting to the observations (Pearson residuals) and in terms of performance of the projected biomasses compared to future estimates of those biomasses in subsequent assessments (i.e. the projected Biomass in Case 2 have smaller retrospective pattern than for Case 1). If future management would move towards setting TACs according to projections this would make Case 2 preferable over Case 1. The retrospective pattern of the recent period in Case 2 is poorer than Case1, but the historical pattern is better (smaller) for Case 2 than for Case 1. Keeping the historical retrospective pattern low has the advantage of stabilizing the inferences on historical productivity (S_R relationships) and on reference points as Blim (if taken from a past year). The subgroup recommends taking Case 2 for the setting of the assessment model for anchovy for the next 3-4 year until next benchmark, and therefore the stock annex should be amended accordingly.

- It is acknowledged that the retrospective pattern in recent years will still be appearing as the reasons for it are not sufficiently understood. Nevertheless, these are a bit smaller than with the former (BBM) model. Summing up some more years of observations should allow further analysis of the way to address this problem in the setting of the assessment for this anchovy and therefore this issue should be re-examined in next benchmark. The magnitude of retrospective pattern for the last years is not considered to be high in comparison to other stocks, but it is considered a problem by fishermen and stakeholders because the fishing opportunities, set by the harvest control rule of the long term management plan, are directly derived from the latest estimate of SSB. For the time being, this pattern can only be reduced to a limited extent without creating other problems such as strong drifts of past SSBs (which could ultimately require re-estimating reference points and the HCR of the management plan almost every year). The assessment method and the management plan are likely to be revised every 3-5 years which might imply setting new model parameters and reference points; It is presumed that in the future this problem might be reduced or fixed as new work and knowledge on this stock would lead to improved assessments.
- ACOM will be informed of the analysis made after WKPELA and it will be asked for approval of the consensus achieved by the subgroup to adopt as the assessment of reference for anchovy the stock annex of WKPELA with the modifications demanded in Annex 3 of that report (Case 2 in this document) and on the catchability model for JUVENA, until a new benchmark is set up. Permissions to amend accordingly the stock annex will be asked. If approved by ACOM this WD will be attached either to the WGHANSA report or to WKPELA.
- Blim and Bpa should be revised accordingly to the new assessment arising from the proposed new stock annex. Such a review will be made by mid September, following in principle the same reasoning applied to define these reference points in WKPELA.

4. REFERENCES

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Table 1: Relative retrospective patterns of assessed biomasses

A- Relative retrospective patterns for the two model setting of the CBBM compared with the assessment that would have been produced in June2013 according to the latest available inputs. Case 1 (on the left) is the VarFixed setting (stock annex in WKPELA) while case 2 (on the right) is the VarEstimated (Annex 3 of WKPELA). Columns refer to the years when the assessment is carried out (in December) and rows refer to the assessed years. The last two rows indicate the relative error in the last assessment year and the average across years.

	Model:VarFixed_Power (Case 1)									Model:VarEstimated_Power (Case 2)							
	2012	**2011**	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**		**2012**	**2011**	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**
1987	0.00	0.02	0.05	0.07	0.12	0.16	0.18	0.23		0.02	0.01	0.02	0.02	0.04	0.08	0.10	0.11
1988	0.01	0.03	0.05	0.06	0.11	0.16	0.17	0.21		0.03	0.00	0.02	0.02	0.03	0.08	0.10	0.11
1989	0.02	0.06	0.08	0.11	0.14	0.21	0.23	0.26		0.04	-0.02	0.03	0.03	0.02	0.09	0.12	0.13
1990	-0.02	0.00	0.02	0.02	0.07	0.10	0.11	0.14		0.01	0.02	0.01	0.00	0.02	0.05	0.05	0.07
1991	-0.04	-0.01	0.01	0.03	0.08	0.12	0.15	0.17		0.01	0.05	0.05	0.03	0.05	0.10	0.08	0.07
1992	-0.01	0.02	0.05	0.07	0.12	0.16	0.18	0.22		-0.01	0.04	0.03	0.02	0.06	0.06	0.09	0.11
1993	0.01	0.03	0.05	0.06	0.10	0.14	0.15	0.19		0.01	0.02	0.03	0.02	0.05	0.06	0.08	0.09
1994	0.03	0.05	0.08	0.09	0.13	0.18	0.19	0.22		0.01	0.01	0.03	0.03	0.06	0.07	0.08	0.11
1995	0.00	0.01	0.05	0.06	0.10	0.15	0.15	0.17		-0.02	-0.04	-0.02	-0.01	0.05	0.03	0.04	0.09
1996	-0.01	0.01	0.04	0.06	0.10	0.14	0.15	0.17		0.01	-0.01	-0.01	0.00	0.05	0.04	0.08	0.10
1997	0.00	0.02	0.05	0.07	0.12	0.16	0.16	0.18		0.01	0.01	0.02	0.01	0.05	0.05	0.09	0.08
1998	0.02	0.04	0.08	0.09	0.14	0.19	0.20	0.22		0.00	0.02	0.07	0.05	0.09	0.12	0.14	0.16
1999	0.00	0.02	0.05	0.06	0.11	0.15	0.16	0.17		0.01	0.00	0.03	0.02	0.05	0.06	0.09	0.09
2000	-0.02	0.03	0.04	0.05	0.11	0.15	0.17	0.20		0.03	0.03	-0.01	0.00	0.04	0.04	0.07	0.07
2001	-0.01	0.02	0.03	0.05	0.11	0.15	0.17	0.19		0.02	0.03	0.02	0.02	0.06	0.07	0.09	0.08
2002	-0.01	0.02	0.03	0.05	0.11	0.16	0.18	0.19		0.01	0.04	0.05	0.06	0.07	0.11	0.13	0.09
2003	-0.01	0.02	0.04	0.05	0.10	0.14	0.16	0.14		0.00	0.03	0.00	0.01	0.03	0.04	0.05	0.00
2004	-0.01	0.03	0.05	0.05	0.11	0.16	0.17	0.08		0.00	0.02	-0.02	-0.04	0.01	-0.01	0.02	-0.10
2005	-0.01	0.03	0.05	0.06	0.12	0.17	0.18	-0.04		0.00	0.01	-0.05	-0.07	-0.03	-0.04	-0.03	-0.23
2006	-0.02	0.03	0.04	0.05	0.08	0.10	0.03			-0.01	0.02	-0.04	-0.11	-0.16	-0.22	-0.24	
2007	-0.02	0.03	0.02	0.02	0.01	-0.02				-0.01	0.01	-0.07	-0.15	-0.22	-0.33		
2008	-0.02	0.03	0.02	0.00	-0.08					-0.01	0.00	-0.07	-0.15	-0.26			
2009	-0.01	0.03	0.01	-0.06						-0.01	0.01	-0.06	-0.18				
2010	0.00	0.02	-0.13							0.00	-0.03	-0.18					
2011	0.01	-0.01								-0.05	-0.12						
2012	0.00									-0.08							
2013																	
Retro of Year Y	0.00	-0.01	-0.13	-0.06	-0.08	-0.02	0.03	-0.04		-0.08	-0.12	-0.18	-0.18	-0.26	-0.33	-0.24	-0.23
Historical Mean Retro	0.00	0.02	0.04	0.05	0.10	0.14	0.16	0.17		0.00	0.01	0.00	-0.02	0.01	0.03	0.06	0.06

B- Summary of the former relative retrospective patterns compared to the retrospective patterns of the former stock annex (BBM, valid up to JUNE 2013)

Model	2013	2012	2011	2010	2009	2008	2007	2006
Current (BBM)	0.00	-0.12	-0.10	-0.21	-0.22	-0.25	-0.33	-0.33
Var.Fixed_Case 1	0.00	-0.01	-0.13	-0.06	-0.08	-0.02	0.03	-0.04
Var.Estim_Case 2	0.00	-0.08	-0.12	-0.18	-0.18	-0.26	-0.33	-0.24

Table 2: Relative performance of projections of Biomass of the two model settings of the CBBM conducted in December compared to A- respective Assessments in June 2013 according to the latest available inputs. B- the assessment updated next year after the Spring surveys for which the projection was provided. Case 1 is the VarFixed setting (stock annex in WKPELA) while Case 2 is the VarEstimated (Annex 3 of WKPELA). Columns refer to the years for which the projections are provided[2].

A- performance of Projections relative to Assessment in June 2013						
	Year Proyected in December Y-1					
Model	2013	2012	2011	2010	2009	2008
Var.Fixed_Case 1	0.15	0.10	-0.25	-0.18	-0.08	-0.02
Var.Estim_Case 2	0.12	0.03	-0.19	-0.13	-0.08	-0.15
B- performance of Projections relative to Assessment in the year projected						
	Year Proyected in December Y-1					
Model	2013	2012	2011	2010	2009	2008
Var.Fixed_Case 1	0.15	0.09	-0.24	-0.05	-0.02	0.06
Var.Estim_Case 2	0.12	0.12	-0.08	0.06	0.11	0.14

[2] Performance analysis of projections for the years prior to 2008 are omitted as the number of JUVENA observations would be too low. Notice that as the JUVENA series started in 2003, the projection for 2008 was based only on 4 pairs of former observations (for recruits survey index in autumn and recruits estimated from next spring surveys) !!!.

Table 3: Summary output of the CBBM assessment of the Bay of Biscay anchovy, following the stock annex of WKPELA but with Power catchability for the JUVENA series and Variance setting of the Spring Survey biomasses as Case 2 (Var.Estimated as Annex 3 of WKPELA).

	Recruitment			SSB			F.sem1			F.sem1		
	5%	50%	95%	5%	50%	95%	5%	50%	95%	5%	50%	95%
1987	12,076	16,147	22,026	16,502	21,435	28,658	0.91	1.19	1.52	0.21	0.31	0.43
1988	26,357	32,209	40,135	24,311	30,034	38,405	0.76	0.98	1.23	0.23	0.31	0.41
1989	6,667	9,377	13,333	11,376	16,406	23,173	0.65	0.91	1.26	0.11	0.16	0.24
1990	59,874	68,872	80,017	47,056	54,869	64,470	0.95	1.18	1.43	0.44	0.58	0.77
1991	17,694	23,156	30,946	22,918	30,675	40,371	0.85	1.11	1.44	0.17	0.24	0.34
1992	72,403	92,042	117,008	57,908	77,009	100,542	0.83	1.11	1.48	0.19	0.29	0.43
1993	51,534	64,861	80,822	64,002	76,479	91,251	0.64	0.81	1.01	0.35	0.47	0.62
1994	35,242	43,045	53,130	41,706	50,932	62,686	0.87	1.09	1.35	0.37	0.50	0.69
1995	38,561	49,513	66,171	34,185	46,253	62,666	1.01	1.36	1.81	0.18	0.27	0.41
1996	42,617	53,637	66,836	43,263	53,167	66,407	0.83	1.08	1.39	0.37	0.52	0.72
1997	37,049	48,050	61,698	42,708	55,793	71,423	0.41	0.53	0.70	0.28	0.39	0.56
1998	71,682	92,967	120,572	76,029	98,194	125,454	0.31	0.41	0.54	0.27	0.39	0.57
1999	30,638	43,478	60,476	54,213	70,369	90,608	0.38	0.51	0.68	0.26	0.36	0.52
2000	73,865	90,219	110,194	76,534	93,280	112,433	0.56	0.70	0.89	0.24	0.33	0.44
2001	62,318	74,608	89,322	78,671	91,202	107,170	0.54	0.65	0.79	0.33	0.43	0.54
2002	9,127	13,030	18,564	31,747	39,140	49,225	0.43	0.55	0.67	0.35	0.46	0.61
2003	15,553	19,634	24,835	22,514	27,703	34,913	0.29	0.38	0.47	0.41	0.56	0.74
2004	24,588	30,333	38,561	24,414	30,871	40,026	0.64	0.84	1.09	0.36	0.52	0.72
2005	2,636	3,942	5,866	10,265	14,291	20,122	0.11	0.16	0.22	NA	NA	NA
2006	13,440	18,864	26,370	16,221	22,222	30,027	0.16	0.22	0.30	0.01	0.01	0.01
2007	16,465	22,697	30,638	24,197	32,421	42,245	0.01	0.01	0.02	NA	NA	NA
2008	6,464	9,173	13,083	19,333	25,169	32,478	NA	NA	NA	NA	NA	NA
2009	7,347	10,199	14,273	16,190	20,776	26,782	NA	NA	NA	NA	NA	NA
2010	35,596	45,707	61,084	37,423	47,177	62,060	0.31	0.41	0.52	0.11	0.16	0.23
2011	79,221	100,710	130,679	84,720	107,123	138,804	0.24	0.32	0.41	0.05	0.06	0.09
2012	28,854	38,949	52,575	66,548	85,539	111,661	0.17	0.22	0.29	0.12	0.16	0.21
2013	21,829	31,257	44,356	42,813	58,475	80,380	0.24	0.33	0.45	NA	NA	NA

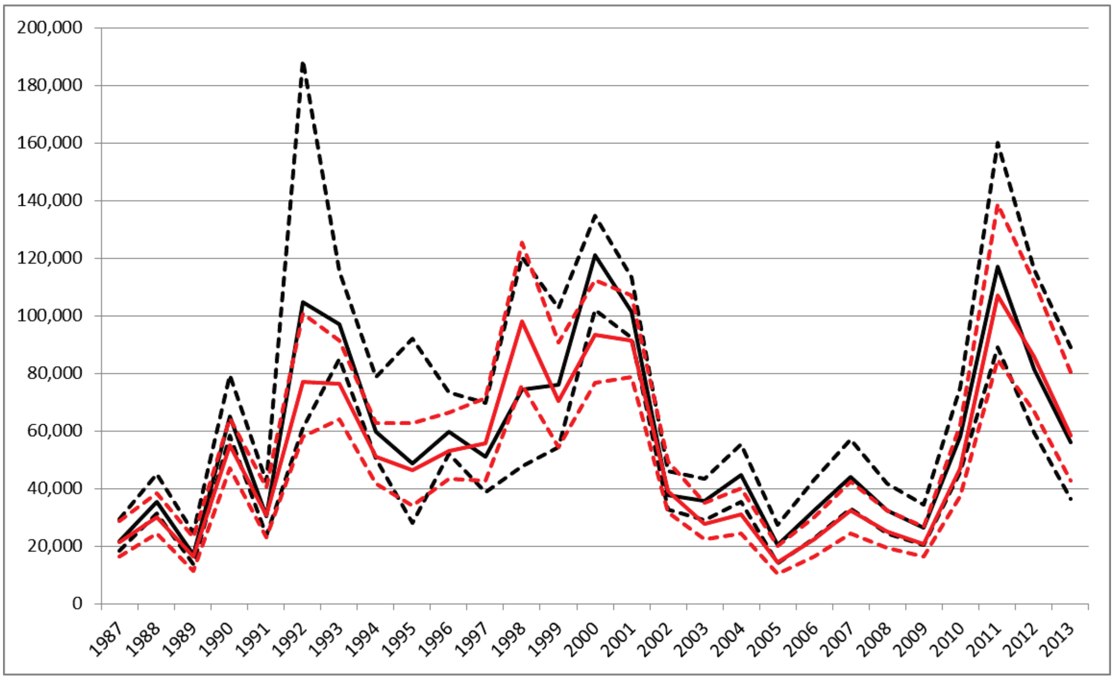

Figure 1: Comparison of the Anchovy Spawning Biomass series from the old BBM model (from the June 2013 WGHANSA assessment- ICES 2013) (in black) and the CBBM of WKPELA settings- but with Power catchability for the JUVENA series and Variance setting of the Spring Survey biomasses as Case 2 (Var.Estimated as Annex 3 of WKPELA) (in Red).

Case 1 (VarFixed setting) Case 2 (VarEstimated-Annex 3 of WKPELA)

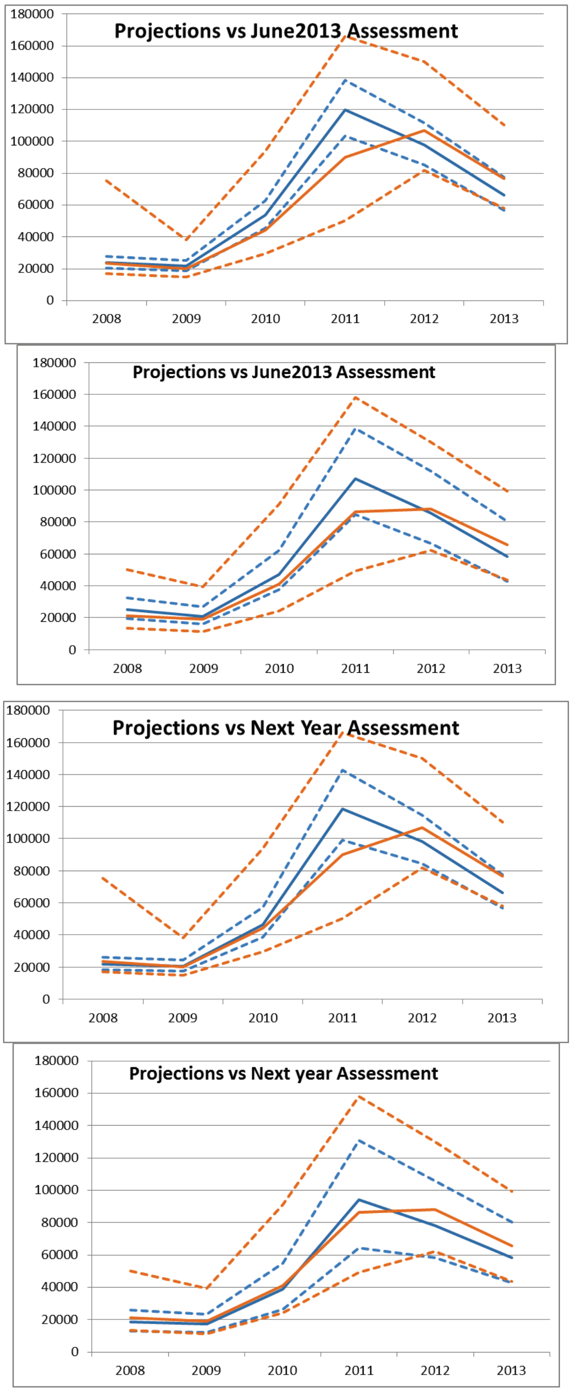

Figure 2: Relative Performance of biomass projections (in Orange) of the two model setting of the CBBM compared to respective Assessments in June 2013 (in blue) according to the latest available inputs (Upper panels) and to the assessment would be carried out after the Spring surveys of the year for which the projection was provided (in blue) (Bottom panels). Left panels correspond with Case 1 which is the VarFixed setting (stock annex in WKPELA) while Right panels correspond with Case 2 which is the VarEstimated (Annex 3 of WKPELA).

Figure3: Retrospective patterns of biomass for Case 2 (Upper figure) and Case 3 (bottom figure).

ANNEX 1

Summary of the analysis regarding pending issues

for Bay of Biscay anchovy from WKPELA

by Leire Ibaibarriaga (July 04, 2013)

1. Introduction

During WKPELA it was not possible to get an agreement on the best way for dealing with the variance of the surveys observation equations in the CBBM. The following cases were considered:

- Case 0: The original version of the CBBM estimates a parameter per survey index related to the variance of the observation equation of each index (see Ibaibarriaga et al. 2011). Not included in this document.
- Case 1: The proposal to fix the variances of the observation equations was initially considered an improvement as they could be used to somehow weight the different observations.
- Case 2: The proposal with the variances of SSB observation equations from the surveys were split into partly fixed and estimated variances was considered a compromise between the two approaches described previously (cases 0 and 1).

In addition, during WGHANSA an additional option was considered:

- Case 3: The variances of SSB observation equations from the surveys were split into two components (observation error plus residual error as in Case 2), but both components were fixed (not estimated).

Finally, this year the final assessment in WGHANSA 2013 was based in the Stock Annex agreed during WKSHORT 2009.

In this document we compile different results with the aim of deciding on the best approach for the CBBM. First, we present and compare the individual runs of the various assessment options (BBM, CBBM case 1, CBBM case2 and CBBM case 3) using the data up to June 2013. Then, a retrospective analysis is conducted.

2. Assessment June 2013

2.1 BBM (final run in WGHANSA 2013)

Table 1: Median and 95% probability intervals for the model parameters as resulted from BBM.

	2.50%	Median	97.50%
qac	0.894	1.148	1.468
psidepm	2.395	4.716	8.725
psiac	2.652	5.566	10.690
xidepm	3.473	5.313	8.296
xiac	3.226	3.966	4.689
mur	10.290	10.610	10.940
psir	0.863	1.498	2.375
B0	34010	38470	47621

Table 2: Median and 95% probability intervals for recruitment, spawning stock biomass, harvest rates (Catch/SSB) and the ratio of SSB with respect to SSB in 1989 as resulted from BBM.

	R (tonnes)			SSB (tonnes)			Harvest rate			SSB/SSB_{1989}		
Year	2.50%	Median	97.50%	2.50%	Median	97.50%	2.50%	Median	97.50%	2.50%	Median	97.50%
1987	14340	16990	22771	18440	21820	29340	0.507	0.681	0.806	0.957	1.286	1.640
1988	35900	41140	51081	31400	35460	45080	0.329	0.418	0.472	1.766	2.082	2.359
1989	9260	11560	15950	13660	17065	24730	0.336	0.487	0.609	1.000	1.000	1.000
1990	81050	89130	105800	58480	65110	79490	0.430	0.524	0.584	2.869	3.792	4.973
1991	20860	26230	34500	23820	30450	42491	0.433	0.604	0.772	1.259	1.759	2.454
1992	87830	140700	241700	60960	104800	188700	0.198	0.357	0.613	3.502	6.008	10.363
1993	33290	89555	126203	85120	97140	115300	0.344	0.408	0.465	3.834	5.705	7.431
1994	39380	48960	65881	50380	59600	78590	0.429	0.566	0.670	2.301	3.481	4.905
1995	35040	56575	101700	27900	48650	91930	0.319	0.604	1.053	1.557	2.774	5.476
1996	37407	67590	88151	51880	59690	73491	0.450	0.554	0.638	2.475	3.477	4.636
1997	39910	52780	71320	38660	50930	69810	0.294	0.402	0.530	1.941	2.957	4.355
1998	54040	82080	132603	47770	74425	120503	0.262	0.424	0.661	2.529	4.322	7.219
1999	41310	78790	117400	54310	75920	102800	0.257	0.348	0.486	2.685	4.387	6.429
2000	107000	131600	154400	101900	121100	134700	0.274	0.305	0.362	4.633	7.079	8.897
2001	75230	84390	101000	92330	101400	113400	0.354	0.396	0.435	4.124	5.945	7.524
2002	10600	12970	18400	32610	37795	46150	0.379	0.463	0.536	1.556	2.214	2.927
2003	24850	31670	38051	29030	35680	43280	0.242	0.294	0.361	1.394	2.084	2.721
2004	36810	46500	57480	35400	44750	55480	0.293	0.364	0.460	1.672	2.617	3.494
2005	4131	6648	9137	14140	20300	27340	0.043	0.057	0.082	0.690	1.186	1.687
2006	20450	29530	39690	22680	32230	42971	0.041	0.055	0.078	1.085	1.883	2.681
2007	26770	36350	48532	32920	43870	57160	0.002	0.003	0.004	1.623	2.554	3.564
2008	8753	12960	18120	24360	32200	41681	0.000	0.000	0.000	1.207	1.876	2.604
2009	9311	13010	18000	20370	26350	34250	0.000	0.000	0.000	0.993	1.541	2.122
2010	48100	61755	81031	45590	57885	74860	0.135	0.175	0.222	2.198	3.385	4.655
2011	96650	128400	176603	89010	117100	160103	0.090	0.124	0.163	4.470	6.800	9.850
2012	26240	37650	57171	59440	81245	116000	0.121	0.173	0.237	3.102	4.685	6.888
2013	21300	32860	53330	36220	56055	88925	0.056	0.088	0.137	1.999	3.194	5.057

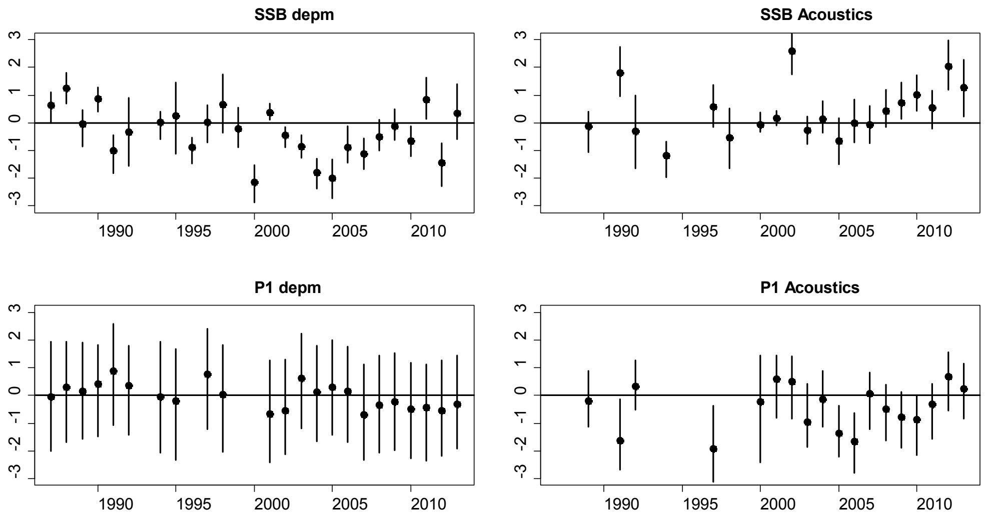

Figure 1: Pearson residuals from BBM.

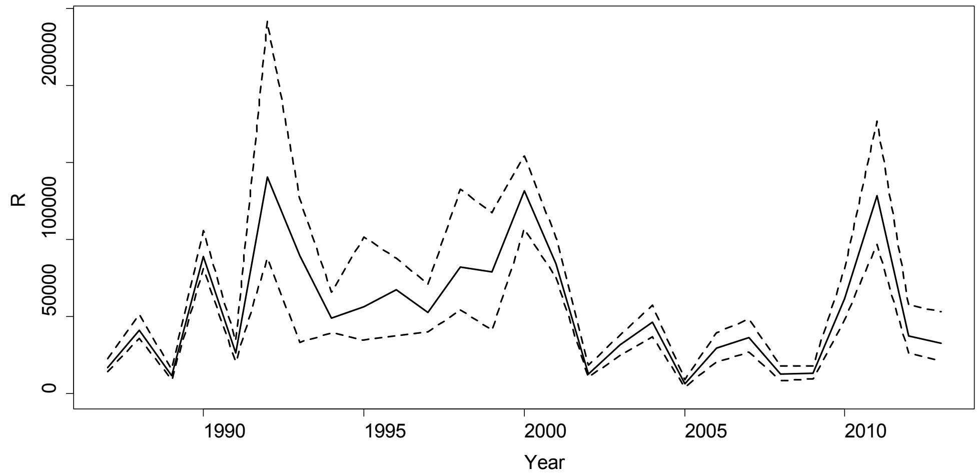

Figure 2: Recruitment time series from BBM.

Figure 3: Spawning stock biomass series from BBM. The solid line is the median and the dashed lines are the 95% probability intervals.

2.2 CBBM case 1 (variances fixed)[3]

Table 3: Median and 95% probability intervals for the model parameters as resulted from CBBM case 1.

	5%	50%	95%
qdepm	0.937	1.050	1.179
qac	1.297	1.449	1.631
qrobs	0.005	0.051	0.735
krobs	1.145	1.413	1.648
psirobs	1.825	4.697	10.690
B0	14328	17292	20994
mur	9.956	10.280	10.590
psir	0.736	1.164	1.742
sage1[1]	0.418	0.468	0.525
sage1[2]	1.243	1.459	1.738
G1	0.540	0.616	0.713
G2	0.226	0.297	0.385
psig	12.530	20.665	31.511

Table 4: Median and 90% probability intervals for recruitment, fishing mortality in the first and second semesters and spawning stock biomass as resulted from CBBM case 1.

	R			Fsem1			fsem2			SSB		
	5%	50%	95%	5%	50%	95%	5%	50%	95%	5%	50%	95%
1987	12296	14846	18088	1.216	1.485	1.811	0.256	0.337	0.449	14598	17785	21715
1988	23624	26903	30946	1.016	1.211	1.433	0.279	0.347	0.436	21700	24765	28435
1989	6148	7692	9557	0.956	1.164	1.409	0.152	0.195	0.259	10408	12736	15544
1990	57526	64861	71718	1.122	1.316	1.535	0.450	0.566	0.714	45597	51081	57227
1991	19226	22925	26903	0.989	1.173	1.397	0.177	0.223	0.281	25398	29923	34949
1992	68872	78433	91126	1.073	1.284	1.541	0.233	0.305	0.395	57309	66495	77882
1993	49021	57526	67508	0.805	0.950	1.117	0.397	0.496	0.617	58620	66610	76198
1994	30333	35596	41773	1.125	1.323	1.552	0.461	0.572	0.730	36209	41739	48061
1995	42193	48533	55826	1.303	1.555	1.837	0.202	0.259	0.332	36667	42446	49298
1996	37421	43478	50514	1.083	1.286	1.527	0.473	0.602	0.771	38298	43998	50825
1997	34892	40946	48050	0.555	0.662	0.797	0.344	0.432	0.547	39839	45965	53272
1998	66171	76880	88433	0.420	0.501	0.597	0.341	0.430	0.544	70888	81191	93159
1999	29733	37798	46630	0.512	0.611	0.731	0.316	0.400	0.507	50073	59014	69078
2000	64861	75358	85819	0.724	0.857	1.007	0.289	0.358	0.446	67499	77186	87490
2001	64216	73865	84965	0.628	0.728	0.847	0.331	0.404	0.493	76318	86262	96908
2002	12161	15123	18527	0.457	0.532	0.623	0.331	0.397	0.483	36564	41900	47732
2003	12185	14647	17536	0.320	0.376	0.444	0.478	0.590	0.732	22457	25827	29669
2004	21764	25084	29144	0.854	1.015	1.204	0.460	0.582	0.732	22400	25761	29766
2005	2135	2928	3870	0.161	0.199	0.244	NA	NA	NA	9349	11324	13643
2006	13454	16597	20292	0.216	0.262	0.316	0.007	0.008	0.011	16358	19426	23172
2007	16269	20191	24835	0.011	0.013	0.016	NA	NA	NA	25653	29847	34855
2008	7079	9605	12645	NA	NA	NA	NA	NA	NA	21923	25484	29470
2009	8317	10679	13467	NA	NA	NA	NA	NA	NA	19433	22466	25864
2010	39340	48050	56954	0.314	0.375	0.451	0.105	0.132	0.169	43861	51966	60552
2011	90219	106938	125492	0.244	0.290	0.344	0.041	0.050	0.063	103404	119386	137160
2012	41773	51534	62318	0.156	0.182	0.211	0.093	0.112	0.135	95582	108840	123356
2013	25336	32860	41357	0.216	0.254	0.296	NA	NA	NA	64823	75164	86838

[3] The assessment from June 2013 which was shown in the WD used by mistake for the cases 1-3 the old DEPM series inputs. However globally (as the DEPM is used as a relative index for which catchability is estimated) the outcome is valid though some concrete parameters might be re-scaled in comparison with outputs from WKPELA.

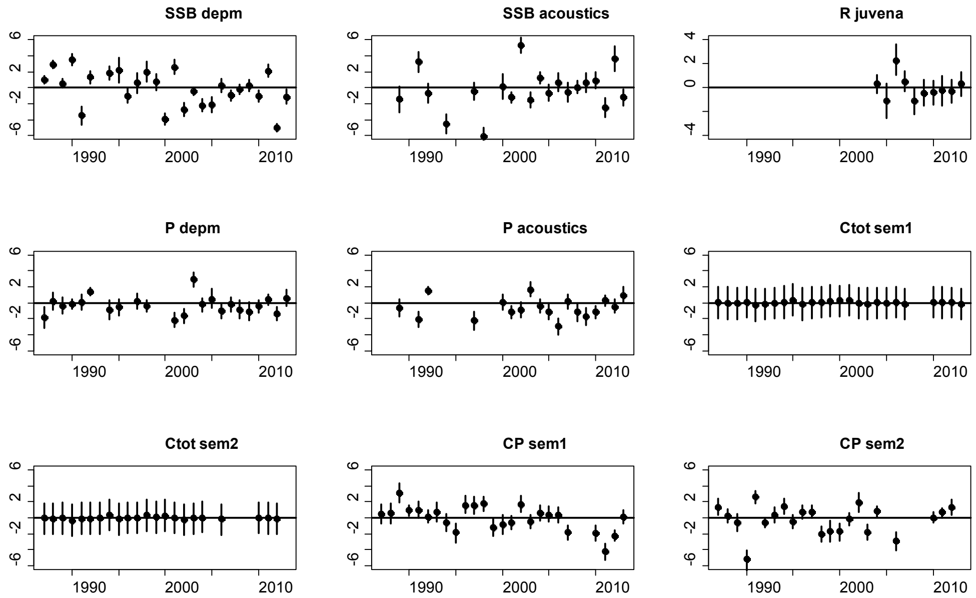

Figure 4: Pearson residuals from CBBM case 1.

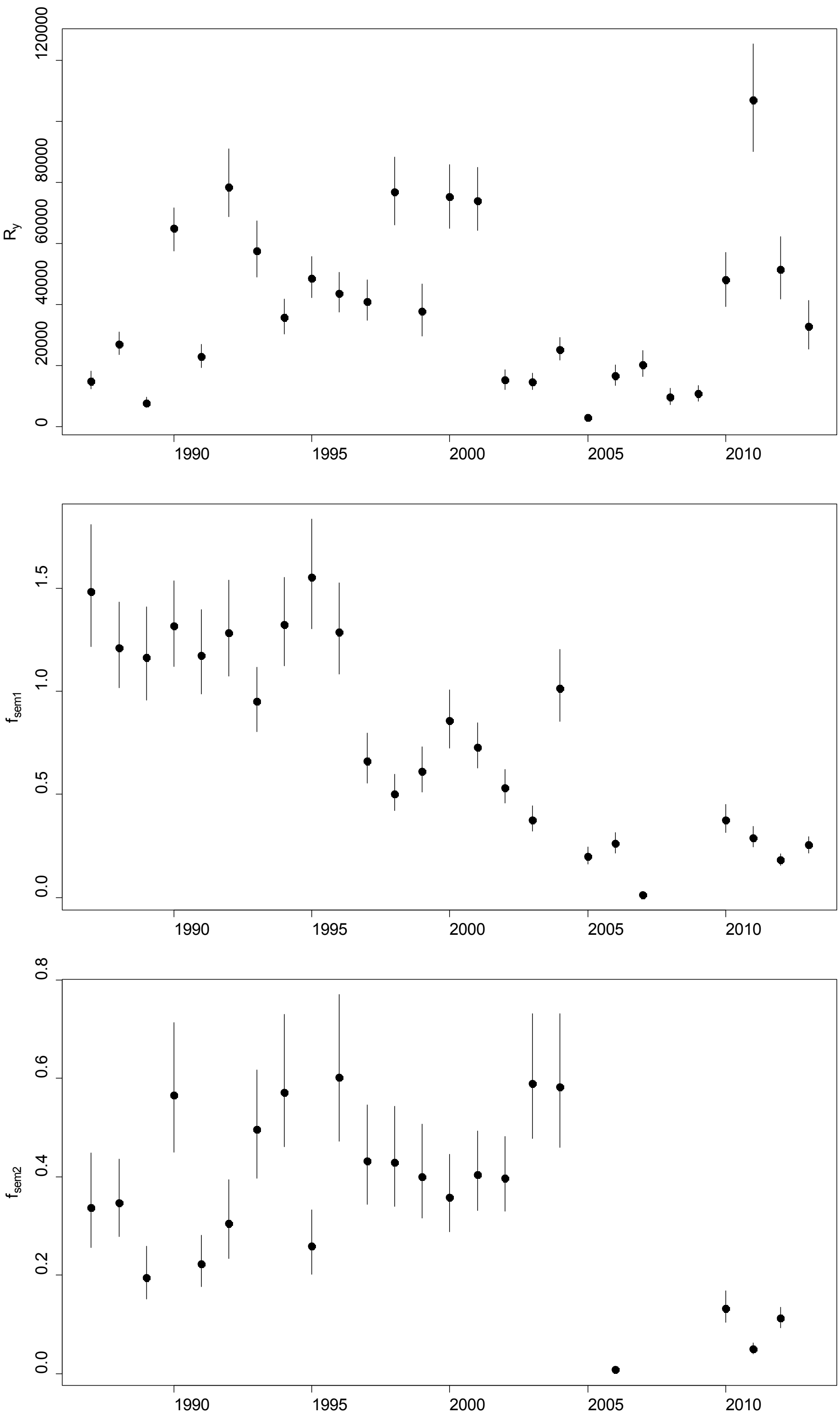

Figure 5: From top to bottom time series of recruitment and fishing mortality in the first and second semesters as resulted from CBBM case 1.

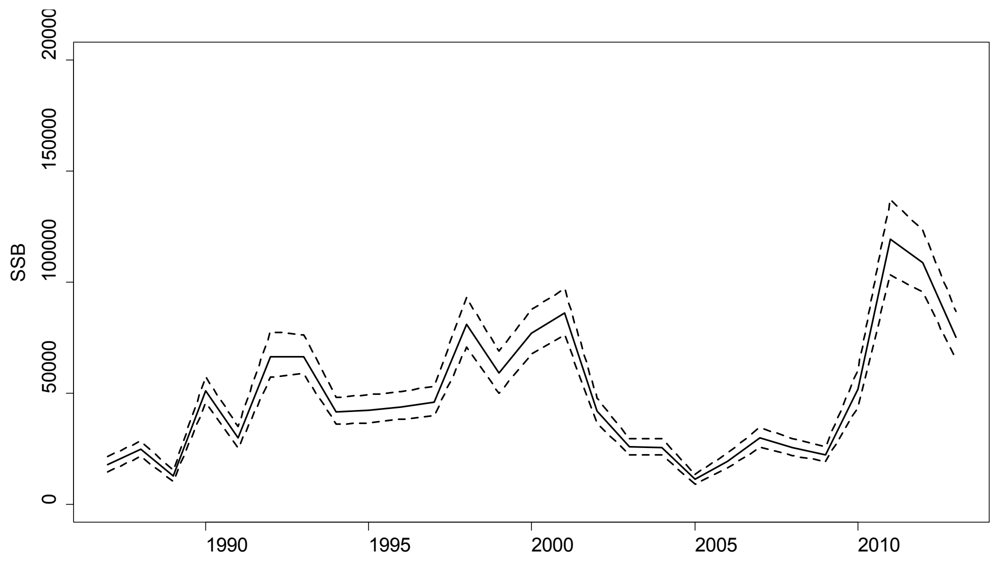

Figure 6: Spawning stock biomass series from CBBM case 1. The solid line is the median and the dashed lines are the 95% probability intervals.

2.3 CBBM case 2[4]

Table 5: Median and 95% probability intervals for the model parameters as resulted from CBBM case 2.

	5%	50%	95%
qdepm	0.780	0.953	1.147
qac	1.060	1.309	1.616
qrobs	0.001	0.016	0.399
krobs	1.215	1.529	1.788
psidepm	4.833	9.174	17.541
psiac	3.700	7.245	13.731
psirobs	1.815	5.215	16.130
xidepm	3.374	4.145	5.160
xiac	3.031	3.731	4.548
xicatch	2.399	2.803	3.228
B0	16865	22004	27723
mur	10.030	10.360	10.670
psir	0.752	1.202	1.820
sage1[1]	0.408	0.489	0.592
sage1[2]	1.071	1.336	1.658
G1	0.488	0.560	0.635
G2	0.182	0.255	0.336
psig	16.148	25.090	36.820

[4] See footnote 3

Table 6: Median and 90% probability intervals for recruitment, fishing mortality in the first and second semesters and spawning stock biomass as resulted from CBBM case 2.

	R			Fsem1			fsem2			SSB		
	5%	50%	95%	5%	50%	95%	5%	50%	95%	5%	50%	95%
1987	12283	15994	21764	0.889	1.173	1.518	0.211	0.296	0.422	16722	21812	28626
1988	26903	32860	40135	0.712	0.942	1.201	0.220	0.294	0.406	25033	31141	39086
1989	7302	9987	14143	0.613	0.845	1.158	0.102	0.147	0.219	12677	17799	24729
1990	57526	66171	76880	0.920	1.171	1.451	0.448	0.596	0.788	45690	53444	63379
1991	16171	21504	29437	0.870	1.155	1.533	0.178	0.257	0.373	21069	28714	38830
1992	73865	93901	118184	0.793	1.092	1.499	0.195	0.279	0.410	58278	78094	100742
1993	51534	66171	83283	0.621	0.775	0.980	0.336	0.447	0.592	66457	79090	94015
1994	31888	40135	50514	0.852	1.071	1.330	0.380	0.513	0.707	40775	50186	62893
1995	37798	49021	64216	0.992	1.386	1.891	0.177	0.272	0.424	32956	44957	62079
1996	40946	51021	64216	0.829	1.113	1.449	0.383	0.544	0.771	41305	50807	64192
1997	35954	46630	60476	0.405	0.548	0.736	0.276	0.398	0.594	40962	53686	70035
1998	70263	91126	120572	0.300	0.414	0.546	0.272	0.397	0.591	74446	95972	125708
1999	28567	42193	59874	0.390	0.513	0.670	0.270	0.368	0.506	54244	69258	87748
2000	75358	92042	112420	0.548	0.688	0.866	0.234	0.313	0.426	78479	94920	114287
2001	60476	73130	89322	0.517	0.639	0.780	0.323	0.423	0.543	78794	91482	109605
2002	9701	13333	18657	0.420	0.534	0.656	0.328	0.446	0.579	32827	39926	50673
2003	16188	20517	25591	0.275	0.353	0.449	0.383	0.515	0.695	23887	29248	36082
2004	24835	30333	38177	0.609	0.794	1.035	0.352	0.487	0.699	25506	32076	40393
2005	2477	3681	5351	0.109	0.150	0.209	NA	NA	NA	10820	14889	20118
2006	14114	19361	26635	0.155	0.211	0.284	0.005	0.008	0.011	17427	23061	30495
2007	18398	24588	32209	0.008	0.011	0.015	NA	NA	NA	27115	34831	44670
2008	6967	9547	13082	NA	NA	NA	NA	NA	NA	21615	27193	34101
2009	7179	9877	13575	NA	NA	NA	NA	NA	NA	17288	21591	26995
2010	33860	43045	56387	0.312	0.411	0.529	0.121	0.169	0.234	36226	45234	58313
2011	76115	95798	125492	0.246	0.329	0.423	0.048	0.065	0.087	81897	102746	131349
2012	27723	37421	51534	0.174	0.229	0.291	0.121	0.163	0.215	65693	82529	106478
2013	21526	30638	42617	0.250	0.339	0.456	NA	NA	NA	42168	57255	76594

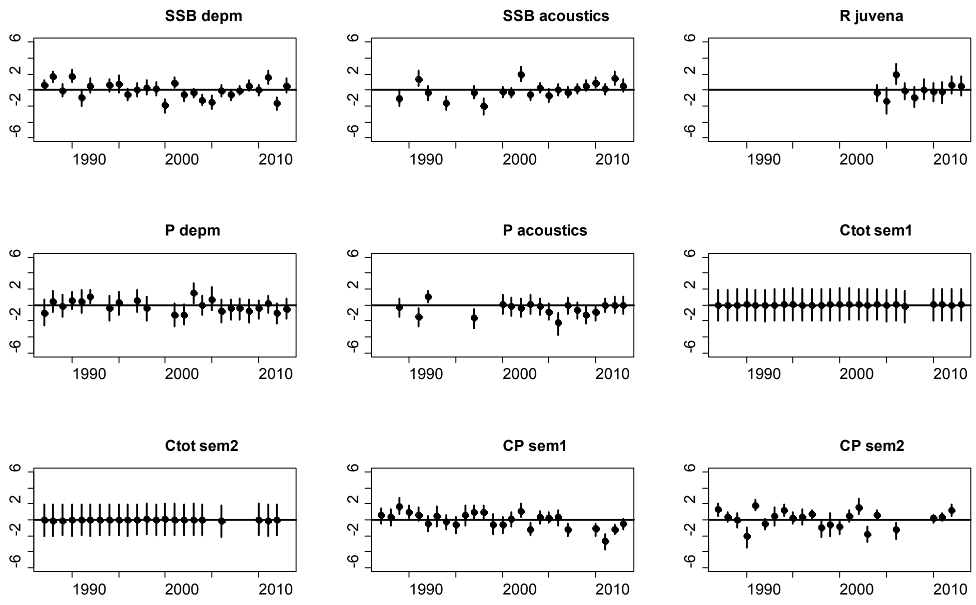

Figure 7: Pearson residuals from CBBM case 2.

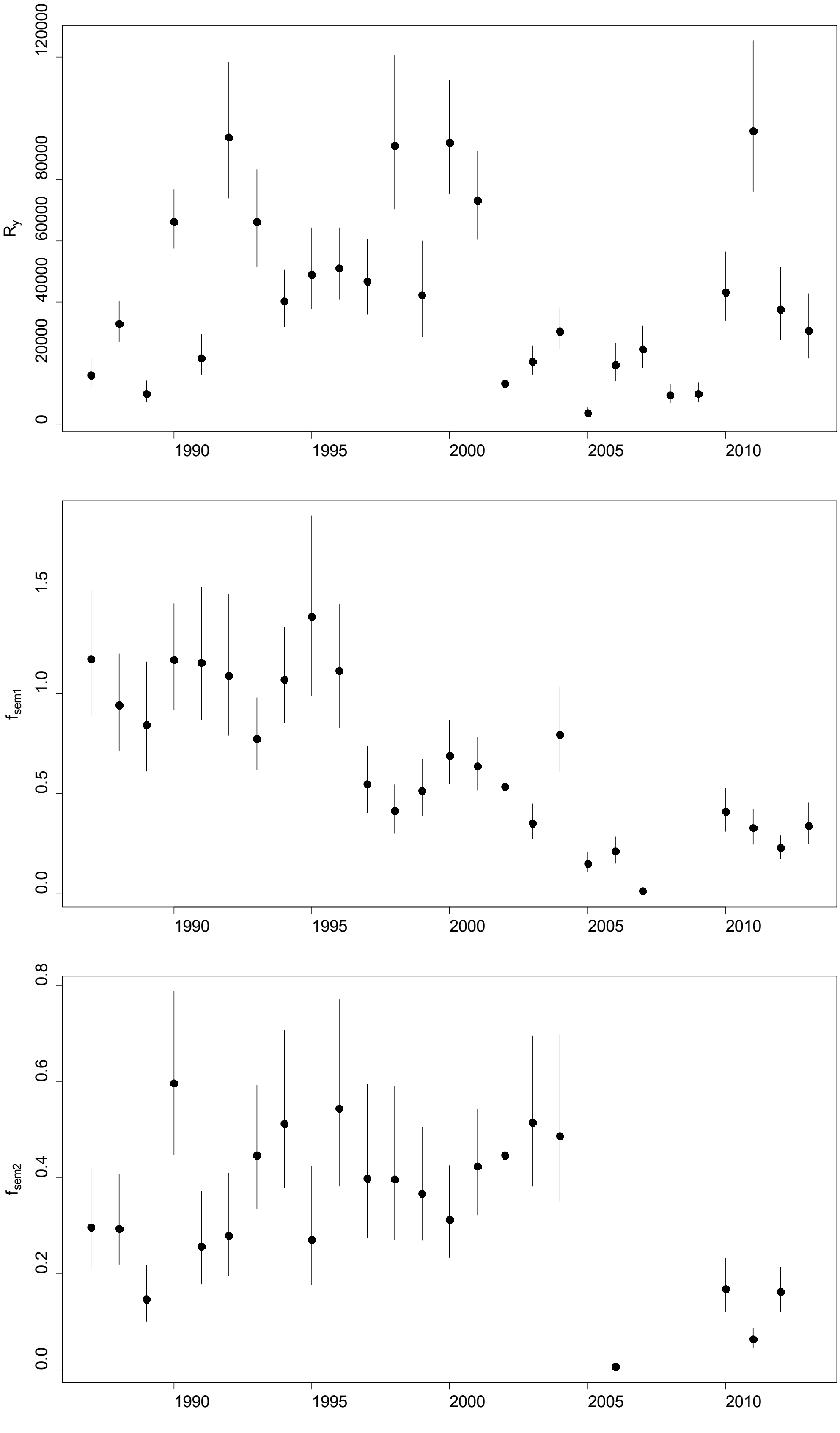

Figure 8: From top to bottom time series of recruitment and fishing mortality in the first and second semesters as resulted from CBBM case 2.

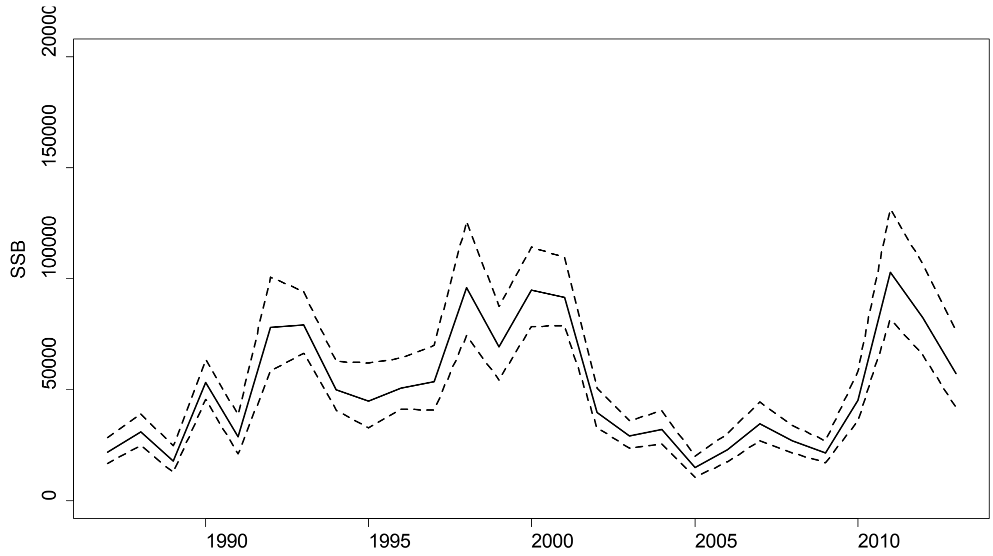

Figure 9: Spawning stock biomass series from CBBM case 2. The solid line is the median and the dashed lines are the 95% probability intervals.

2.4 CBBM case 3[5]

Table 7: Median and 95% probability intervals for the model parameters as resulted from CBBM case 3.

	5%	50%	95%
qdepm	0.805	0.960	1.147
qac	1.083	1.305	1.566
qrobs	0.001	0.011	0.393
krobs	1.217	1.563	1.851
psirobs	1.666	5.020	13.542
B0	15108	18361	22697
mur	10.040	10.340	10.650
psir	0.807	1.260	1.915
sage1[1]	0.426	0.478	0.538
sage1[2]	1.307	1.552	1.811
G1	0.505	0.576	0.656
G2	0.213	0.284	0.367
psig	14.400	22.840	34.351

[5] See footnote 3

Table 8: Median and 90% probability intervals for recruitment, fishing mortality in the first and second semesters and spawning stock biomass as resulted from CBBM case 3.

	R			Fsem1			fsem2			SSB		
	5%	50%	95%	5%	50%	95%	5%	50%	95%	5%	50%	95%
1987	13004	16075	19497	1.090	1.358	1.674	0.223	0.296	0.398	15696	19447	23989
1988	26108	30333	35954	0.859	1.051	1.281	0.220	0.285	0.373	23915	28344	33872
1989	7266	9557	12321	0.734	0.941	1.216	0.109	0.147	0.210	12079	16089	20805
1990	55271	62944	71682	1.067	1.272	1.509	0.436	0.556	0.720	43971	50247	57466
1991	18713	23156	28567	0.963	1.208	1.523	0.166	0.221	0.312	22517	28889	35913
1992	71682	85819	103777	0.937	1.195	1.500	0.197	0.267	0.370	58005	71478	88003
1993	54176	64861	76115	0.695	0.848	1.028	0.331	0.419	0.533	64373	74678	87063
1994	34201	40538	48050	0.926	1.121	1.347	0.364	0.463	0.599	41889	49209	58332
1995	35596	43045	52575	1.209	1.525	1.911	0.201	0.276	0.380	32173	40076	50226
1996	42617	51021	60476	0.978	1.221	1.503	0.383	0.500	0.682	39900	48290	57817
1997	38561	48533	60476	0.431	0.558	0.724	0.252	0.342	0.481	42843	54432	68178
1998	83283	100710	121783	0.304	0.383	0.484	0.230	0.307	0.415	88235	106037	128414
1999	30031	38949	50011	0.376	0.469	0.585	0.249	0.325	0.419	59914	72907	88901
2000	71682	85819	100710	0.583	0.713	0.861	0.229	0.291	0.374	77735	91048	106676
2001	61698	72403	84120	0.560	0.665	0.790	0.311	0.382	0.478	78175	90047	102733
2002	12913	16091	20191	0.432	0.521	0.625	0.301	0.375	0.467	36284	42646	50484
2003	14472	17836	21939	0.282	0.346	0.423	0.384	0.490	0.631	24149	28688	34370
2004	26108	31257	38177	0.642	0.807	1.000	0.318	0.416	0.553	26837	32618	39949
2005	2713	3858	5470	0.109	0.143	0.188	NA	NA	NA	12083	15727	20261
2006	14780	19497	26108	0.158	0.206	0.264	0.005	0.007	0.009	18555	23744	30835
2007	18268	23861	31257	0.009	0.011	0.014	NA	NA	NA	27844	34883	44404
2008	7339	10047	13644	NA	NA	NA	NA	NA	NA	22681	28125	34974
2009	8046	10743	14314	NA	NA	NA	NA	NA	NA	18896	23174	28664
2010	36316	45252	56954	0.305	0.386	0.484	0.103	0.136	0.183	39885	48932	60645
2011	71682	88433	111302	0.268	0.337	0.421	0.046	0.060	0.079	79604	98785	122210
2012	27723	36316	47572	0.187	0.237	0.302	0.117	0.154	0.203	63700	80222	100354
2013	21015	29144	39360	0.264	0.348	0.472	NA	NA	NA	41178	55931	73301

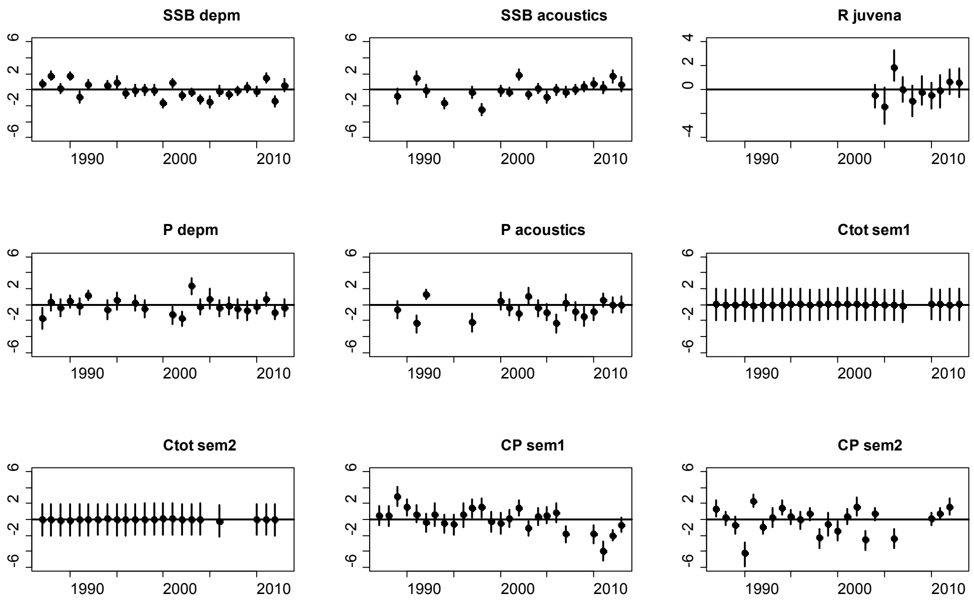

Figure 10: Pearson residuals from CBBM case 3.

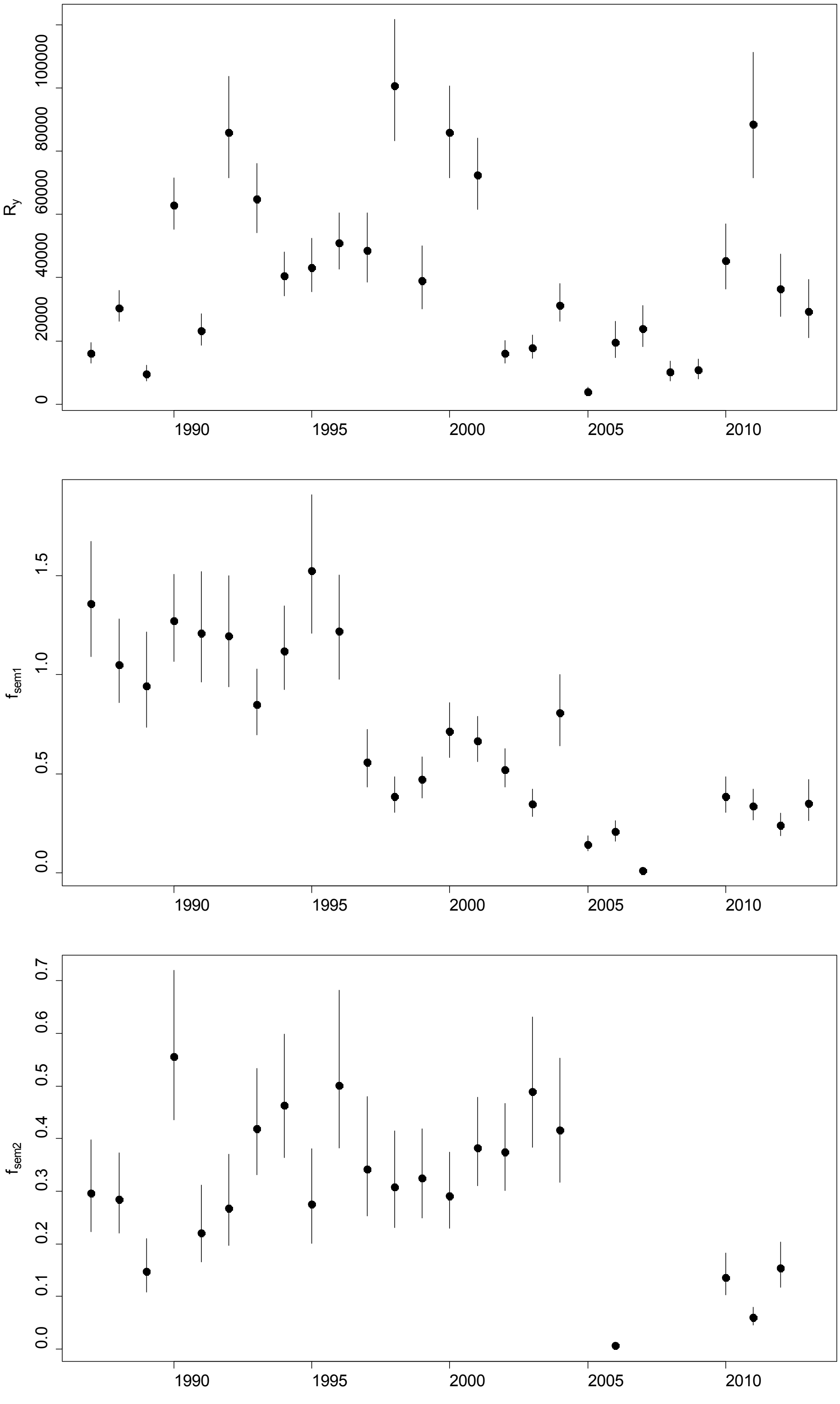

Figure 11: From top to bottom time series of recruitment and fishing mortality in the first and second semesters as resulted from CBBM case 3.

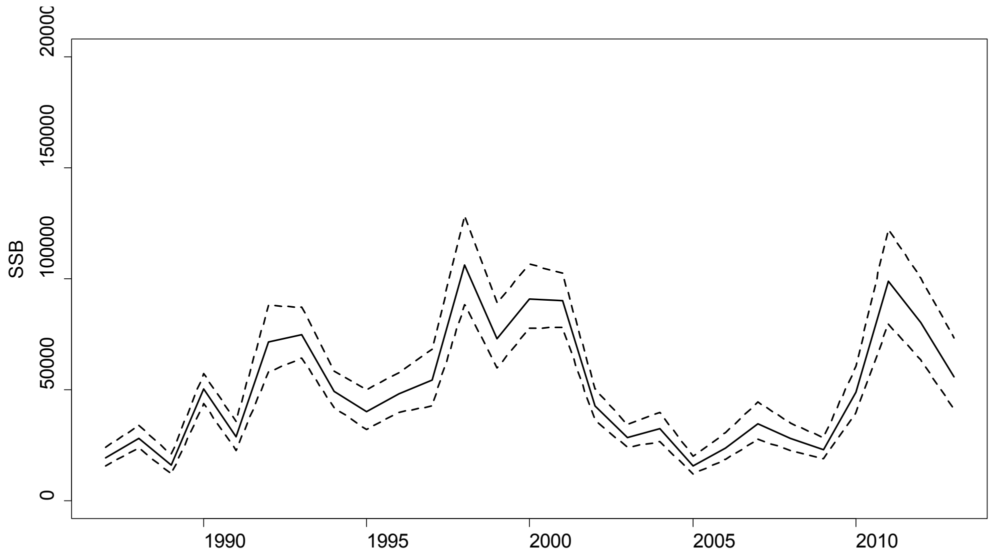

Figure 12: Spawning stock biomass series from CBBM case 3. The solid line is the median and the dashed lines are the 95% probability intervals.

2.5 Comparison

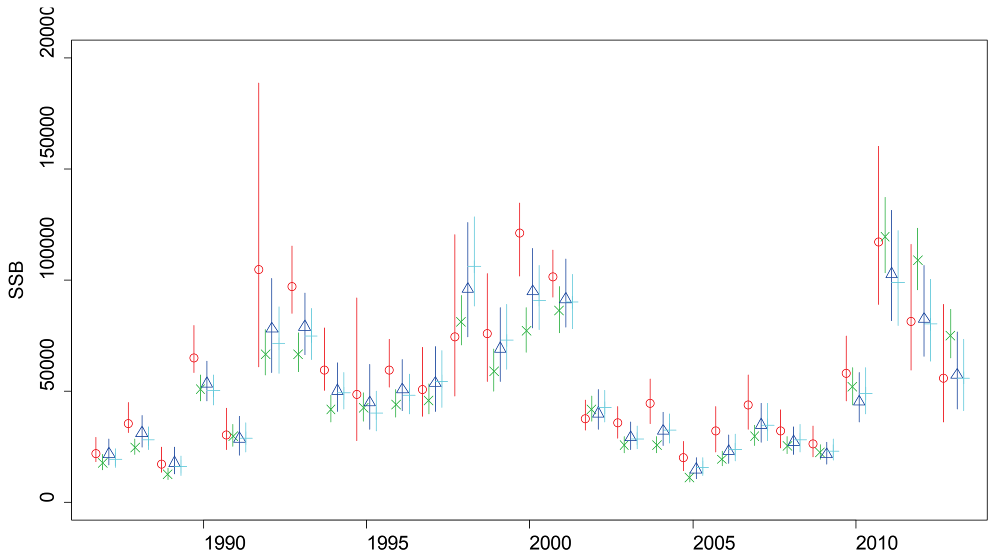

Figure 13: Comparison of SSB for BBM (red circle), CBBM case 1 (green cross), CBBM case 2 (dark blue triangle) and CBBM case 3 (cross light blue).

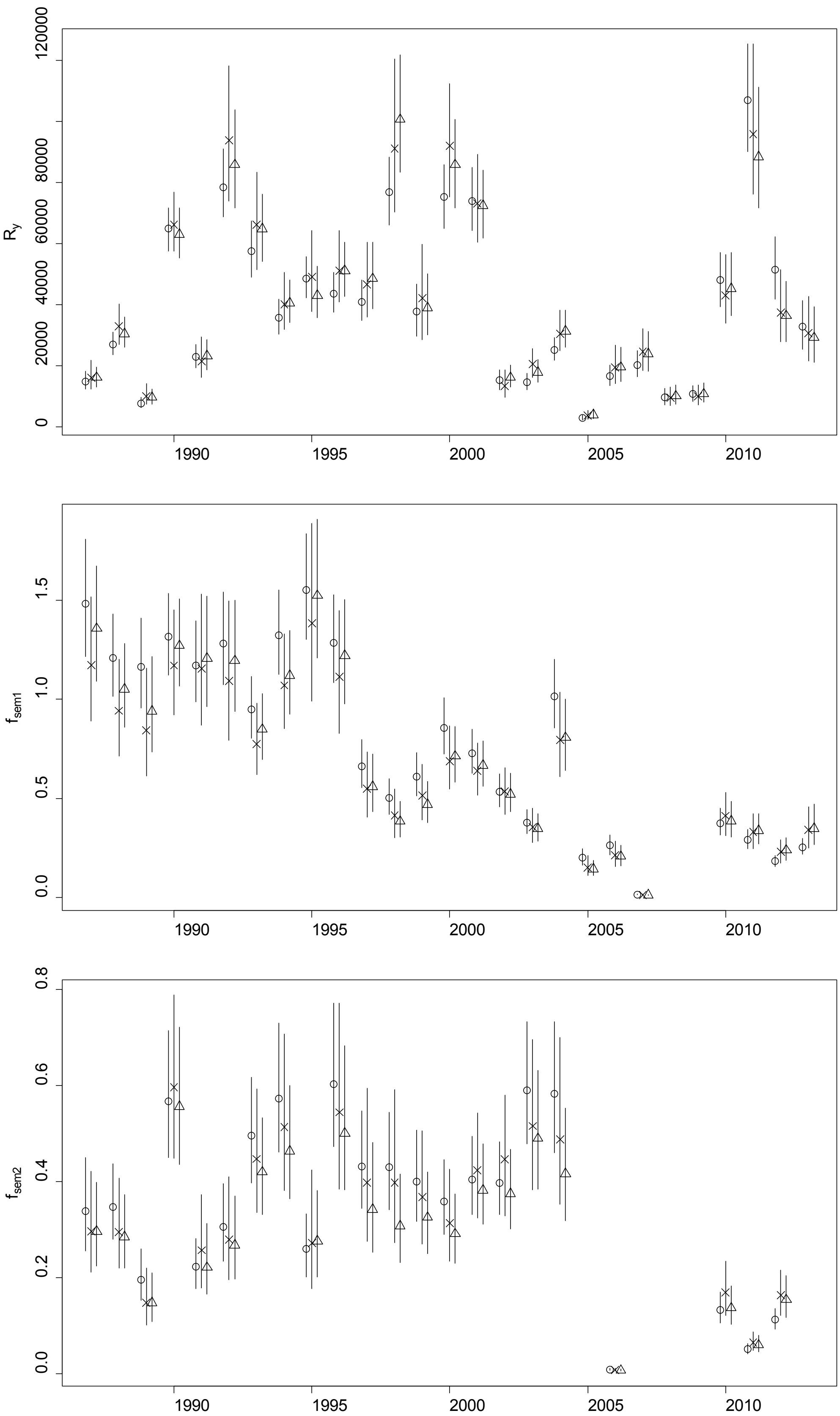

Figure 14: Comparison of recruitment and fishing mortalities in the first and second semesters for the different CBBM settings (circle case 1, cross case 2 and triangle case 3).

2.6 Conclusions

- The trends in recruitment, fishing mortality by semester are similar for the CBBM cases 1-3. Cases 2 and 3 tend to give closer medians, especially for recruitment. Case 1 gives lower median recruitment values and larger fishing mortalities up to 2008, where the contrary occurs. Case 1 gives the narrowest intervals and case 2 the widest ones as expected from the number of parameters fixed in each of them.
- Trend in SSB are similar for BBM and CBBM cases 1-3. However, BBM tends to give larger estimates (note that in BBM depm ssb is absolute, whereas in the CBBM its catchability is estimated). The smallest differences are found between CCBM cases 2 and 3. BBM gives wider intervals, especially in years in which some of the surveys are missing or when the surveys disagree. The additional information coming from the catch data and/or JUVENA in CBBM seems to improve the inference in these cases.
- The difference between the DEPM and acoustic surveys catchability is smaller in the BBM (around 0.15) than in the CBBM (around 0.4). In CBBM the catchability of the DEPM is estimated to be close to 1 and larger than 1 for the acoustic biomass.
- When estimated the residual variance of the DEPM and acoustic surveys (CBBM case 2) is slightly smaller for the DEPM than for acoustics (1/9 vs 1/7). These values are fixed at 7.2 for DEPM and 8.5 for acoustics in CBBM DEPM case 3. The variance related parameters of the age 1 proportion observation equations of DEPM, acoustics and catches are 4.1, 3.7 and 2.8 respectively, whereas in CBBM case 3 are all fixed at 4 (the larger xi, the ??? the variance of the observation equation). Note that in case 3 even if the precision parameter is constant, it does not add linearly in the CV in the original scale.
- The Pearson residuals (which are standardised by the mean and variance of the observation equations) are higher for CBBM case 1 (fixed variances). This means that when precision is fixed, then uncertainty in the results is reduced but with higher residuals, i.e. when we don't model explicitly the residual variance we end up having larger residuals.

3. Retrospective analysis

3.1 BBM (final run in WGHANSA 2013)

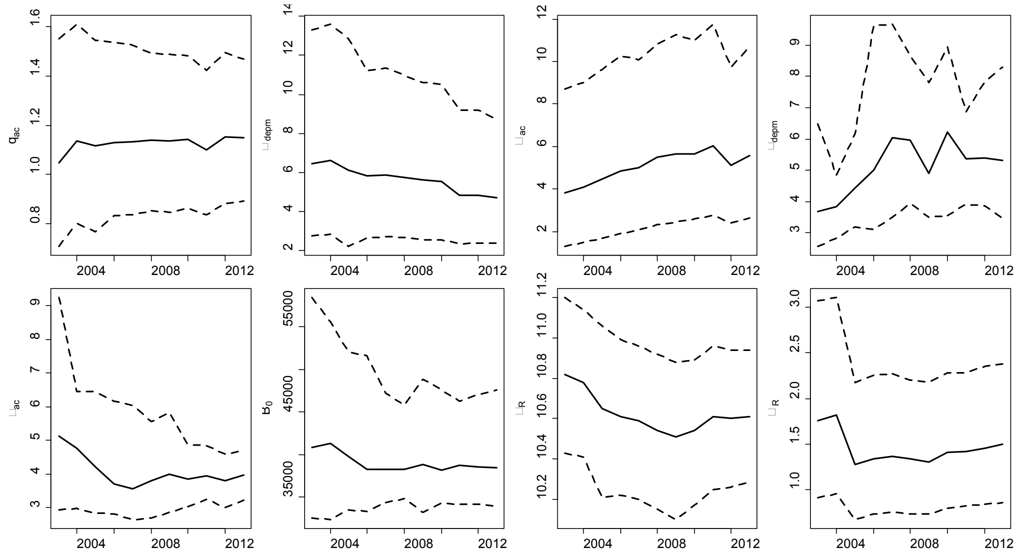

Figure 15: BBM: Retrospective analysis of some of the parameters estimated in the BBM. The solid line is the median and the dashed lines are the 95% probability intervals. The x-axis represents the assessment year.

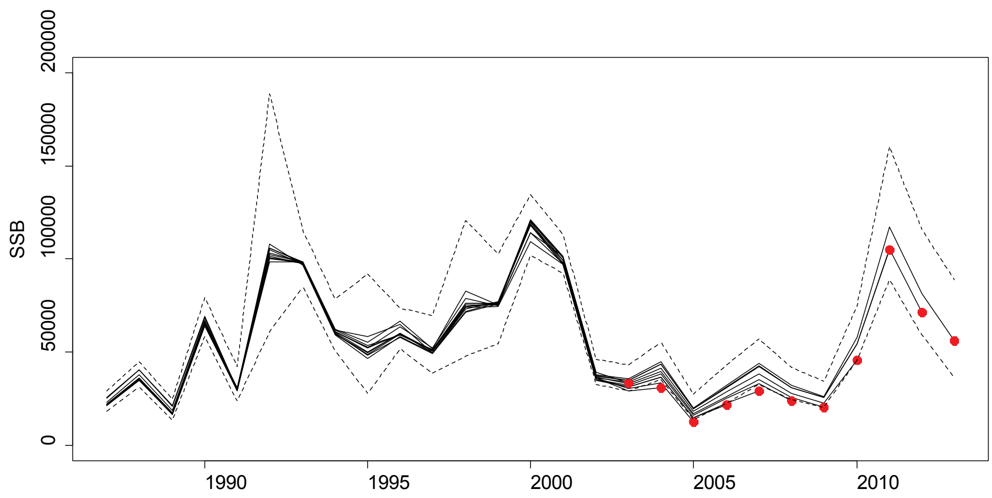

Figure 16: BBM: Retrospective analysis of median SSB time series. The dashed lines represent the 95 % probability intervals of the last assessment conducted in June 2013.

Table 9: BBM: Relative error in median biomass with respect to the assessment conducted in 2013. The columns represent the assessment year, whereas each row is the biomass of a given year.

	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003
Btot[1]	0.00	0.00	0.01	-0.01	0.02	-0.01	-0.02	-0.01	0.07	0.17	0.16
Btot[2]	0.00	0.01	0.01	-0.01	0.02	-0.01	0.00	0.00	0.07	0.14	0.14
Btot[3]	0.00	0.01	0.02	-0.02	0.03	-0.02	0.00	0.00	0.11	0.24	0.24
Btot[4]	0.00	0.00	0.01	-0.01	0.02	-0.02	0.00	-0.01	0.03	0.06	0.05
Btot[5]	0.00	-0.01	0.01	0.00	-0.01	-0.03	0.00	-0.03	-0.02	-0.01	-0.03
Btot[6]	0.00	-0.04	0.01	0.03	-0.03	-0.04	0.01	-0.05	-0.06	-0.02	-0.02
Btot[7]	0.00	0.01	0.01	0.00	0.00	0.01	0.02	0.01	0.01	0.02	0.01
Btot[8]	0.00	0.03	0.02	-0.01	0.00	0.01	0.03	0.01	0.02	0.04	0.04
Btot[9]	0.00	0.09	0.07	-0.04	0.02	-0.01	0.10	0.03	0.08	0.20	0.14
Btot[10]	0.00	0.00	0.00	-0.02	0.01	-0.03	-0.01	0.01	0.07	0.09	0.12
Btot[11]	0.00	0.00	0.00	-0.03	-0.03	-0.03	0.01	0.00	0.03	-0.03	0.02
Btot[12]	0.00	0.01	0.00	-0.03	-0.02	-0.04	0.02	0.02	0.06	-0.01	0.11
Btot[13]	0.00	-0.01	0.01	0.01	0.01	0.00	0.00	0.00	-0.01	-0.02	-0.01
Btot[14]	0.00	0.00	-0.01	0.00	-0.02	-0.01	-0.02	-0.02	-0.06	-0.10	-0.06
Btot[15]	0.00	-0.01	0.00	-0.02	-0.02	-0.03	-0.04	-0.04	-0.04	-0.04	0.00
Btot[16]	0.00	-0.02	0.00	-0.04	-0.03	-0.07	-0.08	-0.07	-0.04	-0.04	0.04
Btot[17]	0.00	-0.02	-0.02	-0.05	-0.07	-0.09	-0.12	-0.12	-0.14	-0.18	-0.06
Btot[18]	0.00	-0.02	-0.03	-0.07	-0.11	-0.14	-0.18	-0.18	-0.24	-0.31	NA
Btot[19]	0.00	-0.03	-0.04	-0.10	-0.17	-0.20	-0.27	-0.28	-0.38	NA	NA
Btot[20]	0.00	-0.02	-0.04	-0.11	-0.19	-0.22	-0.30	-0.33	NA	NA	NA
Btot[21]	0.00	-0.03	-0.04	-0.13	-0.19	-0.25	-0.33	NA	NA	NA	NA
Btot[22]	0.00	-0.03	-0.04	-0.13	-0.20	-0.25	NA	NA	NA	NA	NA
Btot[23]	0.00	-0.03	-0.03	-0.14	-0.22	NA	NA	NA	NA	NA	NA
Btot[24]	0.00	-0.06	-0.06	-0.21	NA	NA	NA	NA	NA	NA	NA
Btot[25]	0.00	-0.10	-0.10	NA	NA	NA	NA	NA	NA	NA	NA
Btot[26]	0.00	-0.12	NA	NA	NA	NA	NA	NA	NA	NA	NA
Btot[27]	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
qac	0.00	0.00	-0.04	0.00	-0.01	-0.01	-0.01	-0.01	-0.03	-0.01	-0.09
psidepm	0.00	0.03	0.02	0.17	0.20	0.22	0.25	0.23	0.30	0.41	0.37
psiac	0.00	-0.08	0.08	0.01	0.02	-0.01	-0.10	-0.13	-0.20	-0.27	-0.32
xidepm	0.00	0.02	0.01	0.17	-0.08	0.12	0.14	-0.06	-0.17	-0.28	-0.31
xiac	0.00	-0.04	0.00	-0.03	0.01	-0.04	-0.10	-0.06	0.06	0.20	0.29
B0	0.00	0.00	0.01	-0.01	0.01	-0.01	-0.01	-0.01	0.03	0.07	0.06
mur	0.00	0.00	0.00	-0.01	-0.01	-0.01	0.00	0.00	0.00	0.02	0.02
psir	0.00	-0.03	-0.05	-0.06	-0.13	-0.11	-0.09	-0.10	-0.15	0.22	0.18

Table 10: BBM: Relative error in median biomass with respect to the next year assessment. The columns represent the assessment year, whereas each row is the biomass of a given year.

Btot[1]		0.00	0.01	-0.02	0.03	-0.03	0.00	0.01	0.08	0.10	-0.01
Btot[2]		0.01	0.01	-0.02	0.03	-0.03	0.01	0.00	0.07	0.07	0.00
Btot[3]		0.01	0.01	-0.04	0.05	-0.04	0.01	0.00	0.11	0.12	0.00
Btot[4]		0.00	0.01	-0.01	0.02	-0.03	0.02	-0.01	0.04	0.03	-0.01
Btot[5]		-0.01	0.02	-0.01	-0.01	-0.02	0.03	-0.03	0.02	0.00	-0.02
Btot[6]		-0.04	0.05	0.02	-0.06	-0.01	0.05	-0.06	-0.01	0.04	0.01
Btot[7]		0.01	-0.01	-0.01	0.01	0.00	0.01	-0.01	0.00	0.00	0.00
Btot[8]		0.03	0.00	-0.03	0.01	0.00	0.03	-0.02	0.01	0.02	0.00
Btot[9]		0.09	-0.01	-0.11	0.07	-0.03	0.11	-0.06	0.04	0.11	-0.05
Btot[10]		0.00	0.01	-0.03	0.03	-0.04	0.02	0.02	0.06	0.02	0.03
Btot[11]		0.00	-0.01	-0.02	0.00	0.00	0.04	-0.01	0.03	-0.05	0.05
Btot[12]		0.01	-0.01	-0.03	0.02	-0.02	0.06	0.00	0.04	-0.06	0.12
Btot[13]		-0.01	0.02	0.00	0.01	-0.01	0.00	0.00	-0.02	-0.01	0.01
Btot[14]		0.00	0.00	0.00	-0.02	0.01	0.00	-0.01	-0.03	-0.04	0.04
Btot[15]		-0.01	0.01	-0.02	0.00	-0.02	-0.01	0.00	0.01	-0.01	0.05
Btot[16]		-0.02	0.01	-0.04	0.02	-0.04	-0.02	0.02	0.03	0.00	0.08
Btot[17]		-0.02	0.00	-0.03	-0.02	-0.03	-0.03	0.00	-0.03	-0.04	0.15
Btot[18]		-0.02	-0.01	-0.05	-0.04	-0.03	-0.05	0.00	-0.07	-0.08	NA
Btot[19]		-0.03	-0.01	-0.07	-0.07	-0.04	-0.08	-0.02	-0.14	NA	NA
Btot[20]		-0.02	-0.02	-0.08	-0.09	-0.03	-0.10	-0.05	NA	NA	NA
Btot[21]		-0.03	-0.01	-0.09	-0.07	-0.07	-0.11	NA	NA	NA	NA
Btot[22]		-0.03	0.00	-0.10	-0.08	-0.07	NA	NA	NA	NA	NA
Btot[23]		-0.03	0.00	-0.11	-0.09	NA	NA	NA	NA	NA	NA
Btot[24]		-0.06	0.00	-0.16	NA	NA	NA	NA	NA	NA	NA
Btot[25]		-0.10	-0.01	NA	NA	NA	NA	NA	NA	NA	NA
Btot[26]		-0.12	NA	NA	NA	NA	NA	NA	NA	NA	NA
Btot[27]		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
qac		0.00	-0.05	0.04	-0.01	0.00	-0.01	0.00	-0.01	0.02	-0.08
psidepm		0.03	-0.01	0.15	0.02	0.02	0.02	-0.01	0.05	0.08	-0.03
psiac		-0.08	0.18	-0.06	0.00	-0.03	-0.09	-0.03	-0.08	-0.09	-0.06
xidepm		0.02	0.00	0.16	-0.21	0.21	0.01	-0.17	-0.11	-0.13	-0.04
xiac		-0.04	0.04	-0.03	0.04	-0.05	-0.06	0.04	0.13	0.13	0.07
B0		0.00	0.00	-0.01	0.02	-0.02	0.00	0.00	0.04	0.04	-0.01
mur		0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00
psir		-0.03	-0.02	-0.01	-0.07	0.03	0.02	-0.02	-0.05	0.42	-0.03

3.2 CBBM case 1 (December assessment)[6]

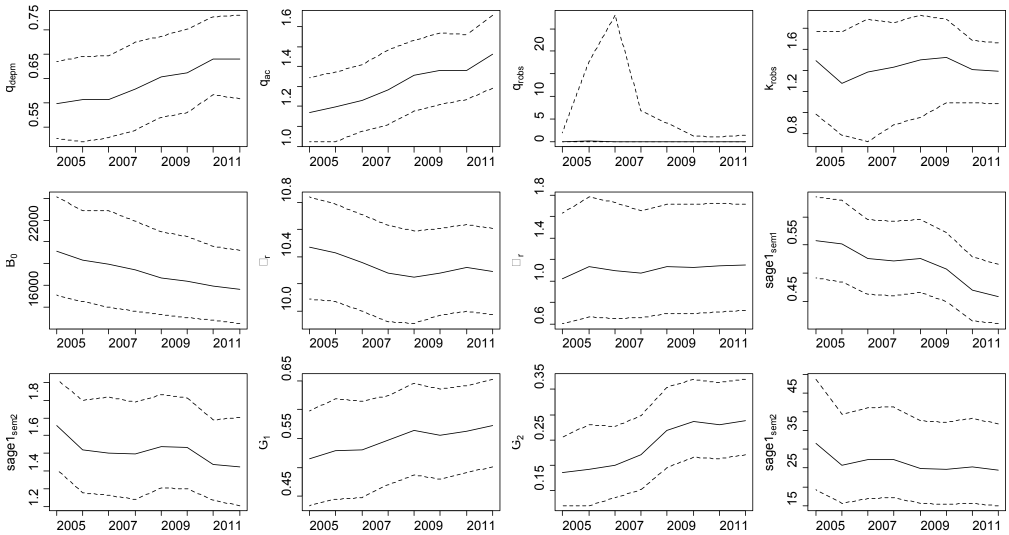

Figure 17: CBBM case 1: Retrospective analysis of some of the parameters estimated. The solid line is the median and the dashed lines are the 90% probability intervals. The x-axis represents the assessment year.

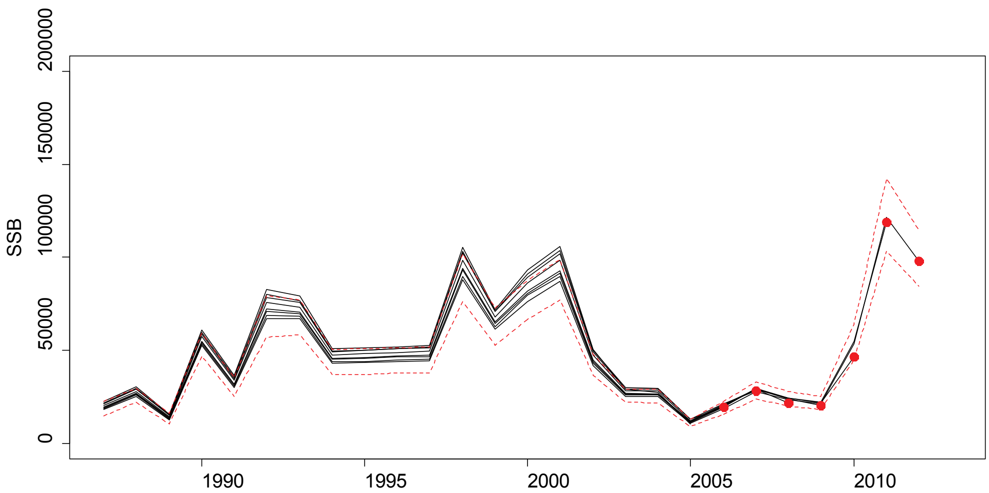

Figure 18: CBBM case 1: Retrospective analysis of median SSB time series. The dashed lines represent the 90 % probability intervals of the last assessment conducted in June 2013.

[6] All inputs correct and coherent with WKPELA

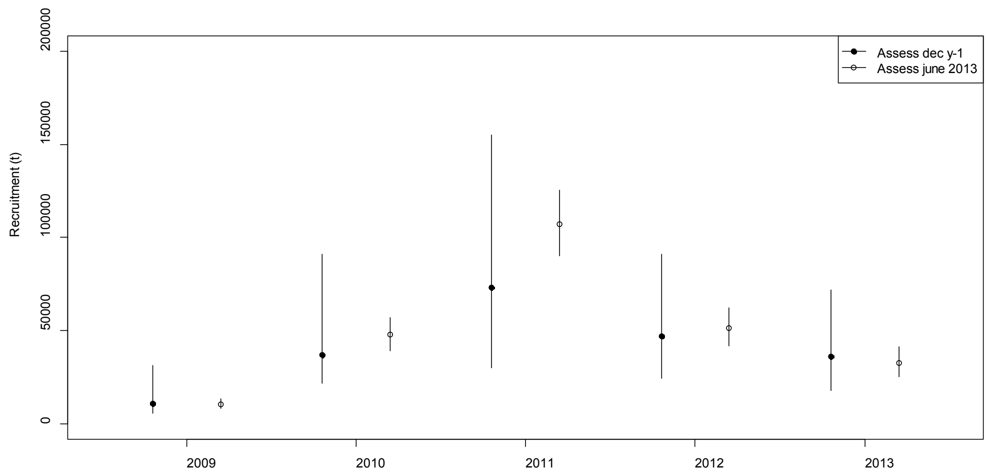

Figure 19: CBBM case 1: Comparison of R each year as estimated from the previous year December assessment and the latest assessment in June 2013.

Table 11: CBBM case 1: Relative error in median biomass with respect to the assessment conducted in December 2012. The columns represent the assessment year, whereas each row is the biomass of a given year.

	2012	2011	2010	2009	2008	2007	2006	2005
1987	0.00	0.03	0.05	0.07	0.12	0.16	0.19	0.24
1988	0.00	0.03	0.04	0.06	0.10	0.15	0.16	0.20
1989	0.00	0.04	0.05	0.08	0.12	0.18	0.20	0.23
1990	0.00	0.02	0.04	0.04	0.09	0.12	0.13	0.16
1991	0.00	0.03	0.06	0.07	0.13	0.17	0.20	0.22
1992	0.00	0.03	0.06	0.08	0.13	0.17	0.20	0.23
1993	0.00	0.02	0.04	0.05	0.10	0.13	0.15	0.18
1994	0.00	0.02	0.05	0.06	0.10	0.14	0.15	0.18
1995	0.00	0.01	0.05	0.06	0.11	0.15	0.15	0.17
1996	0.00	0.02	0.05	0.07	0.11	0.15	0.16	0.18
1997	0.00	0.02	0.06	0.07	0.12	0.16	0.17	0.19
1998	0.00	0.02	0.06	0.07	0.12	0.16	0.17	0.20
1999	0.00	0.02	0.04	0.06	0.10	0.15	0.15	0.17
2000	0.00	0.05	0.06	0.07	0.13	0.17	0.19	0.22
2001	0.00	0.03	0.05	0.06	0.13	0.17	0.19	0.21
2002	0.00	0.03	0.05	0.07	0.13	0.18	0.20	0.21
2003	0.00	0.03	0.05	0.06	0.11	0.15	0.17	0.15
2004	0.00	0.03	0.05	0.06	0.12	0.16	0.18	0.08
2005	0.00	0.05	0.07	0.08	0.14	0.19	0.20	-0.02
2006	0.00	0.05	0.06	0.07	0.10	0.12	0.05	
2007	0.00	0.05	0.05	0.05	0.04	0.00		
2008	0.00	0.04	0.03	0.02	-0.07			
2009	0.00	0.04	0.02	-0.04				
2010	0.00	0.02	-0.13					
2011	0.00	-0.02						
2012	0.00							
2013								

Table 12: CBBM case 1: Relative error in median biomass with respect to the next year assessment. The columns represent the assessment year, whereas each row is the biomass of a given year.

	2012	2011	2010	2009	2008	2007	2006	2005
1987	0.00	0.03	0.03	0.01	0.05	0.04	0.02	0.04
1988	0.00	0.03	0.01	0.01	0.04	0.04	0.01	0.03
1989	0.00	0.04	0.02	0.03	0.03	0.06	0.02	0.02
1990	0.00	0.02	0.02	0.01	0.05	0.03	0.01	0.03
1991	0.00	0.03	0.03	0.01	0.06	0.04	0.02	0.02
1992	0.00	0.03	0.03	0.02	0.04	0.04	0.02	0.03
1993	0.00	0.02	0.02	0.01	0.04	0.03	0.01	0.03
1994	0.00	0.02	0.02	0.01	0.04	0.04	0.01	0.02
1995	0.00	0.01	0.04	0.01	0.04	0.04	0.00	0.02
1996	0.00	0.02	0.03	0.01	0.04	0.04	0.00	0.02
1997	0.00	0.02	0.04	0.01	0.04	0.04	0.00	0.02
1998	0.00	0.02	0.04	0.01	0.04	0.04	0.01	0.02
1999	0.00	0.02	0.02	0.01	0.04	0.04	0.00	0.01
2000	0.00	0.05	0.01	0.01	0.05	0.04	0.02	0.02
2001	0.00	0.03	0.02	0.02	0.06	0.04	0.02	0.02
2002	0.00	0.03	0.02	0.02	0.05	0.04	0.02	0.01
2003	0.00	0.03	0.01	0.02	0.04	0.04	0.02	-0.02
2004	0.00	0.03	0.02	0.01	0.06	0.04	0.01	-0.08
2005	0.00	0.05	0.02	0.01	0.05	0.04	0.01	-0.19
2006	0.00	0.05	0.01	0.01	0.03	0.02	-0.07	
2007	0.00	0.05	0.00	0.00	-0.01	-0.03		
2008	0.00	0.04	-0.01	-0.01	-0.09			
2009	0.00	0.04	-0.02	-0.07				
2010	0.00	0.02	-0.15					
2011	0.00	-0.02						
2012	0.00							
2013								

3.3 CBBM case 2 (December assessment)[7]

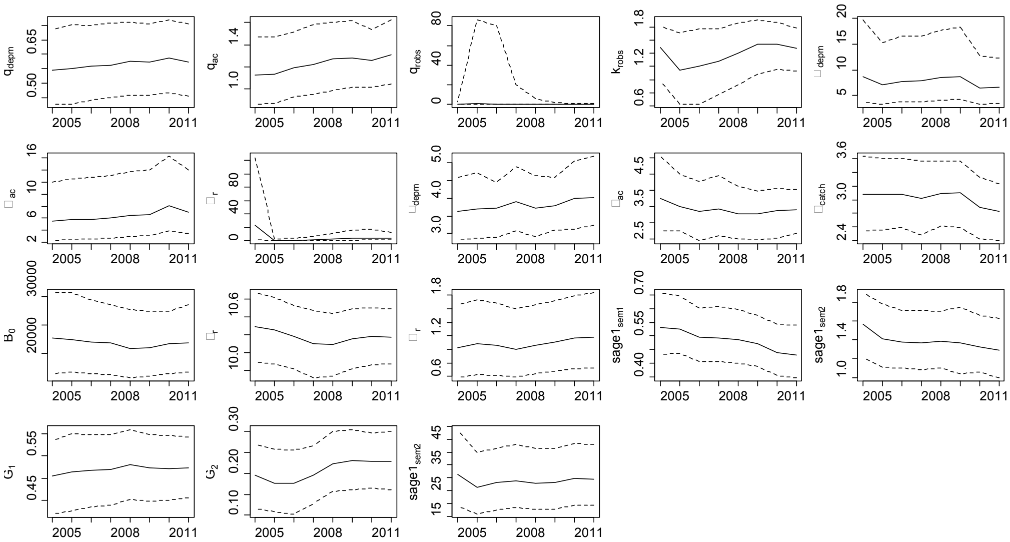

Figure 20: CBBM case 2: Retrospective analysis of some of the parameters estimated. The solid line is the median and the dashed lines are the 90% probability intervals. The x-axis represents the assessment year.

[7] All inputs correct and coherent with WKPELA

Figure 21: CBBM case 2: Retrospective analysis of median SSB time series. The dashed lines represent the 90 % probability intervals of the last assessment conducted in June 2013.

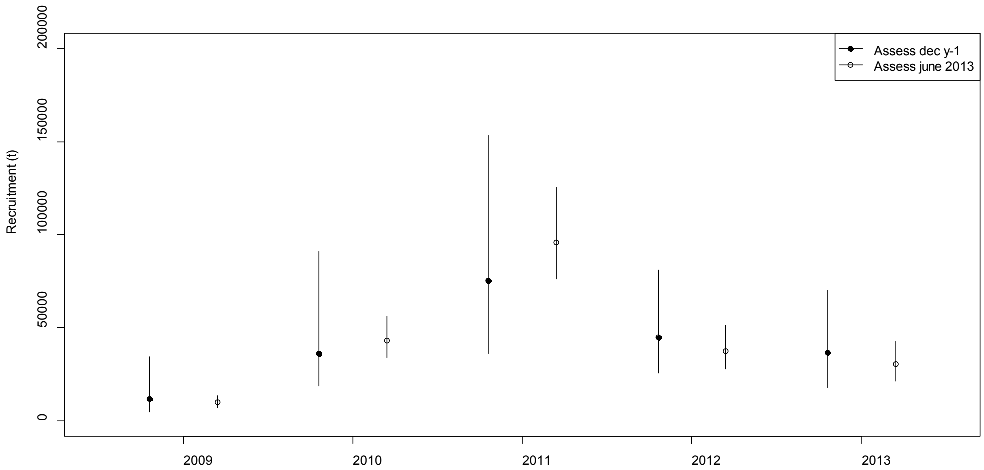

Figure 22: CBBM case 2: Comparison of R each year as estimated from the previous year December assessment and the latest assessment in June 2013.

Table 13: CBBM case 2: Relative error in median biomass with respect to the assessment conducted in December 2012. The columns represent the assessment year, whereas each row is the biomass of a given year.

	2012	2011	2010	2009	2008	2007	2006	2005
1987	0.00	-0.01	0.00	0.00	0.01	0.06	0.08	0.09
1988	0.00	-0.03	-0.01	-0.01	0.00	0.05	0.07	0.08
1989	0.00	-0.05	-0.01	0.00	-0.02	0.05	0.08	0.08
1990	0.00	0.01	0.01	-0.01	0.02	0.04	0.04	0.07
1991	0.00	0.03	0.04	0.02	0.04	0.09	0.06	0.06
1992	0.00	0.04	0.04	0.02	0.06	0.07	0.10	0.12
1993	0.00	0.01	0.01	0.01	0.04	0.05	0.06	0.08
1994	0.00	0.00	0.02	0.02	0.05	0.06	0.07	0.10
1995	0.00	-0.02	0.00	0.01	0.08	0.05	0.06	0.11
1996	0.00	-0.02	-0.02	-0.01	0.04	0.03	0.07	0.09
1997	0.00	0.00	0.01	0.00	0.04	0.04	0.08	0.08
1998	0.00	0.02	0.07	0.05	0.09	0.12	0.14	0.16
1999	0.00	-0.01	0.01	0.01	0.04	0.05	0.07	0.08
2000	0.00	0.00	-0.03	-0.03	0.02	0.01	0.04	0.04
2001	0.00	0.01	0.00	0.00	0.04	0.05	0.07	0.05
2002	0.00	0.03	0.03	0.05	0.05	0.10	0.11	0.08
2003	0.00	0.02	0.00	0.00	0.02	0.03	0.04	0.00
2004	0.00	0.01	-0.02	-0.04	0.01	-0.01	0.02	-0.10
2005	0.00	0.01	-0.05	-0.08	-0.03	-0.05	-0.03	-0.23
2006	0.00	0.03	-0.03	-0.10	-0.15	-0.21	-0.23	
2007	0.00	0.02	-0.06	-0.14	-0.21	-0.32		
2008	0.00	0.01	-0.05	-0.14	-0.25			
2009	0.00	0.01	-0.05	-0.17				
2010	0.00	-0.02	-0.18					
2011	0.00	-0.08						
2012	0.00							
2013								

Table 14: CBBM case 2: Relative error in median biomass with respect to the next year assessment. The columns represent the assessment year, whereas each row is the biomass of a given year.

	2012	2011	2010	2009	2008	2007	2006	2005
1987	0.00	-0.01	0.01	0.00	0.02	0.04	0.02	0.01
1988	0.00	-0.03	0.02	0.00	0.01	0.04	0.02	0.01
1989	0.00	-0.05	0.05	0.00	-0.01	0.06	0.03	0.00
1990	0.00	0.01	0.00	-0.01	0.02	0.03	0.00	0.02
1991	0.00	0.03	0.01	-0.02	0.02	0.05	-0.02	0.00
1992	0.00	0.04	-0.01	-0.01	0.04	0.01	0.03	0.02
1993	0.00	0.01	0.01	-0.01	0.03	0.01	0.01	0.01
1994	0.00	0.00	0.02	0.00	0.03	0.01	0.01	0.02
1995	0.00	-0.02	0.03	0.00	0.07	-0.02	0.01	0.05
1996	0.00	-0.02	0.00	0.01	0.05	-0.01	0.03	0.02
1997	0.00	0.00	0.01	-0.01	0.04	0.00	0.04	-0.01
1998	0.00	0.02	0.06	-0.02	0.03	0.03	0.02	0.02
1999	0.00	-0.01	0.03	0.00	0.03	0.01	0.02	0.01
2000	0.00	0.00	-0.03	0.00	0.05	-0.01	0.04	-0.01
2001	0.00	0.01	-0.02	0.01	0.03	0.01	0.02	-0.01
2002	0.00	0.03	0.01	0.01	0.00	0.04	0.01	-0.03
2003	0.00	0.02	-0.02	0.00	0.02	0.01	0.01	-0.04
2004	0.00	0.01	-0.04	-0.02	0.05	-0.01	0.02	-0.12
2005	0.00	0.01	-0.06	-0.03	0.05	-0.02	0.02	-0.21
2006	0.00	0.03	-0.06	-0.06	-0.06	-0.07	-0.03	
2007	0.00	0.02	-0.08	-0.08	-0.09	-0.13		
2008	0.00	0.01	-0.07	-0.09	-0.13			
2009	0.00	0.01	-0.06	-0.13				
2010	0.00	-0.02	-0.16					
2011	0.00	-0.08						
2012	0.00							
2013								

3.4 CBBM case 3 (December assessment)[8]

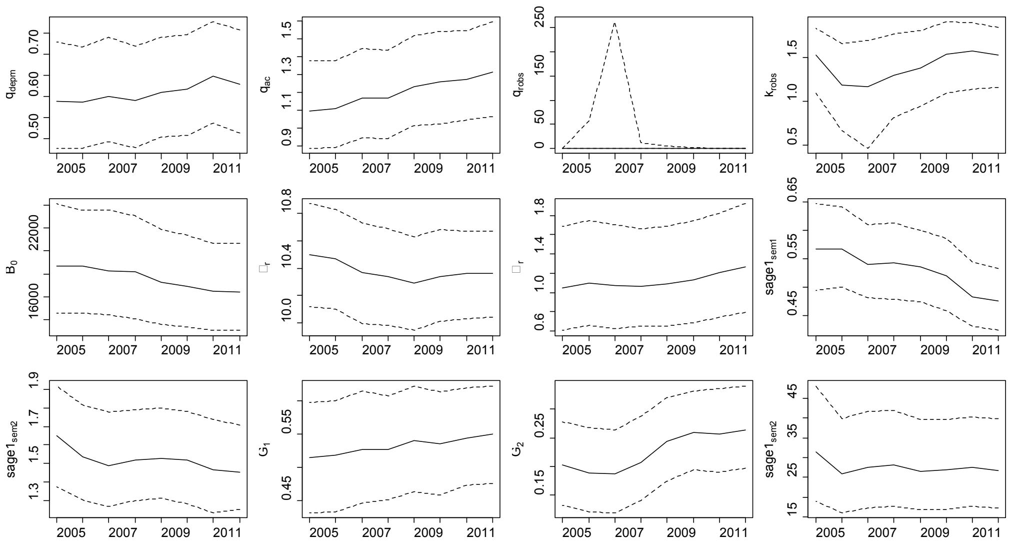

Figure 23: CBBM case 3: Retrospective analysis of some of the parameters estimated. The solid line is the median and the dashed lines are the 90% probability intervals. The x-axis represents the assessment year.

Figure 24: CBBM case 3: Retrospective analysis of median SSB time series. The dashed lines represent the 90 % probability intervals of the last assessment conducted in June 2013.

[8] All inputs correct and coherent with WKPELA

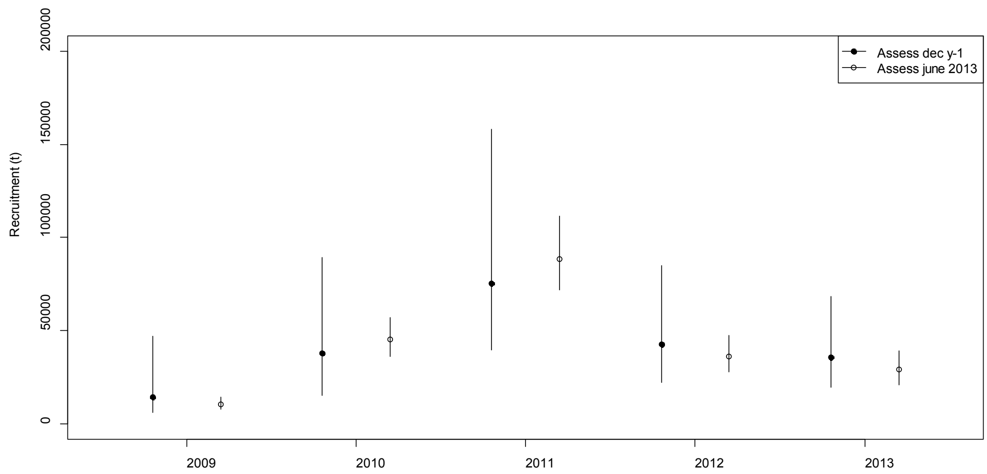

Figure 25: CBBM case 3: Comparison of R each year as estimated from the previous year December assessment and the latest assessment in June 2013.

Table 15: CBBM case 3: Relative error in median biomass with respect to the assessment conducted in December 2012. The columns represent the assessment year, whereas each row is the biomass of a given year.

1987	0.00	0.00	0.03	0.04	0.10	0.10	0.13	0.12
1988	0.00	0.01	0.02	0.03	0.09	0.10	0.12	0.11
1989	0.00	0.01	0.03	0.03	0.09	0.12	0.13	0.12
1990	0.00	0.01	0.03	0.03	0.07	0.07	0.11	0.11
1991	0.00	0.01	0.03	0.05	0.09	0.09	0.15	0.14
1992	0.00	0.00	0.06	0.06	0.11	0.11	0.16	0.18
1993	0.00	0.01	0.04	0.05	0.09	0.09	0.13	0.14
1994	0.00	0.01	0.04	0.04	0.09	0.09	0.13	0.13
1995	0.00	0.01	0.05	0.06	0.12	0.13	0.16	0.16
1996	0.00	0.01	0.05	0.06	0.11	0.12	0.16	0.15
1997	0.00	0.01	0.05	0.06	0.12	0.12	0.17	0.16
1998	0.00	0.01	0.04	0.05	0.11	0.11	0.15	0.15
1999	0.00	0.01	0.03	0.04	0.09	0.09	0.12	0.12
2000	0.00	0.01	0.03	0.04	0.09	0.09	0.13	0.11
2001	0.00	0.01	0.03	0.04	0.10	0.10	0.12	0.10
2002	0.00	0.01	0.04	0.05	0.10	0.09	0.12	0.08
2003	0.00	0.01	0.03	0.04	0.08	0.05	0.07	0.00
2004	0.00	0.00	0.03	0.02	0.07	0.01	0.01	-0.11
2005	0.00	0.00	0.01	0.01	0.05	-0.04	-0.05	-0.24
2006	0.00	0.00	-0.01	-0.07	-0.09	-0.22	-0.24	
2007	0.00	-0.01	-0.05	-0.12	-0.19	-0.34		
2008	0.00	-0.01	-0.07	-0.15	-0.25			
2009	0.00	-0.02	-0.10	-0.22				
2010	0.00	-0.06	-0.23					
2011	0.00	-0.14						
2012	0.00							
2013								

Table 16: CBBM case 3: Relative error in median biomass with respect to the next year assessment. The columns represent the assessment year, whereas each row is the biomass of a given year.

	2012	2011	2010	2009	2008	2007	2006	2005
1987	0.00	0.00	0.03	0.02	0.05	0.01	0.02	-0.01
1988	0.00	0.01	0.02	0.01	0.05	0.01	0.02	-0.01
1989	0.00	0.01	0.02	0.00	0.06	0.02	0.01	-0.01
1990	0.00	0.01	0.02	0.01	0.03	0.00	0.03	0.00
1991	0.00	0.01	0.03	0.02	0.04	0.00	0.06	0.00
1992	0.00	0.00	0.05	0.00	0.05	0.00	0.05	0.01
1993	0.00	0.01	0.03	0.01	0.04	0.00	0.03	0.01
1994	0.00	0.01	0.03	0.01	0.04	0.00	0.03	0.00
1995	0.00	0.01	0.04	0.01	0.05	0.01	0.03	0.00
1996	0.00	0.01	0.03	0.02	0.05	0.00	0.04	-0.01
1997	0.00	0.01	0.03	0.02	0.05	0.00	0.04	-0.01
1998	0.00	0.01	0.03	0.01	0.05	0.00	0.03	0.00
1999	0.00	0.01	0.02	0.01	0.05	0.00	0.03	0.00
2000	0.00	0.01	0.02	0.01	0.05	0.00	0.03	-0.01
2001	0.00	0.01	0.02	0.01	0.05	0.00	0.02	-0.02
2002	0.00	0.01	0.02	0.01	0.05	-0.01	0.02	-0.04
2003	0.00	0.01	0.03	0.00	0.04	-0.03	0.02	-0.06
2004	0.00	0.00	0.02	0.00	0.04	-0.05	0.00	-0.13
2005	0.00	0.00	0.02	-0.01	0.04	-0.09	-0.01	-0.20
2006	0.00	0.00	-0.01	-0.06	-0.03	-0.14	-0.03	1.25
2007	0.00	-0.01	-0.04	-0.08	-0.07	-0.19	0.56	0.00
2008	0.00	-0.01	-0.06	-0.09	-0.12	0.06	0.00	0.00
2009	0.00	-0.02	-0.08	-0.13				
2010	0.00	-0.06	-0.18					
2011	0.00	-0.14						
2012	0.00							
2013								

3.5 Conclusions

- The retrospective pattern in biomass for CBBM case 1 is lower in the last years but higher in the past. Other parameters showing a trend in the retrospective analysis are: qdepm, qac, B0, age 1 selectivity in the first semester, G1 and G2.
- The retrospective pattern in biomass for CBBM cases 2 and 3 is larger in the last years and smaller in the past.
- Regarding the past performance of the December assessment when estimating next year recruitment (based mainly on the last JVUENA survey) is similar in all the cases. The probability intervals are much narrower in the June assessment, when more information is available. The probability intervals of the JUVENA assessment contain always the recruitment as assessed in June 2013.

Annex 8.2 Stock Annex:Bay of Biscay Anchovy (Subarea VIII)

Stock	Bay of Biscay Anchovy (Subarea VIII)
Working Group	WGHANSA (Working Group on the Assessment of Southern Horse Mackerel, Anchovy and Sardine)
Date	October 2013
Revised at	WKPELA 2013 and during & after WGHANSA2013 and approved by ICES ACOM
Authors	G. Boyra, E. Duhamel, L. Ibaibarriaga, J. Massé, L. Pawlowski, M. Santos and A. Uriarte.

A. General

A.1. Stock definition

The Anchovy (*Engraulis encrasicolus* L) inhabiting Subarea VIII (Bay of Biscay) is considered to be isolated from a small population in the English Channel and from the populations in western Iberia (Division IXa) (Magoulas *et al*., 2006; Zarraonaindia *et al*., 2012). Morfometrics and meristic studies suggest some heterogeneity at least in morphotipes (Prouzet and Metuzals, 1994; Junquera and Pérez-Gandaras, 1993). Along the North of Spain (in Division VIIIc) Junquera and Pérez-Gandaras (1993) had already reported significant morphological differences in anchovies between Galicia, Asturias, and the Basque Country, and recently Borrell *et al*. (2012) have pointed out that there is some genetic isolation of anchovies in the middle west side of this division from the eastern one. In addition, some genetic heterogeneity, based on proteins *allocime loci*, have been found between the Garonne spawning regions and southern regions in the Bay of Biscay (Adour and Cantabrian shores) (Sanz *et al*., 2008). Despite the evidences for some heterogeneity and perhaps subpopulation in parts of the Bay of Biscay (western Cantabria), there are ample evidences that the major part of the population inhabits the Eastern and northern parts of the Bay of Biscay and show rather homogenous recruitment pulses and have a rather well understood common spatial dynamics throughout the year (Uriarte *et al*., 1996). This leads ICES to consider that the anchovy in this area should be dealt as a single stock for assessment and management.

A.2. Fishery

The fisheries were closed from July 2005 to December 2009 due to poor condition of the stock. It was reopened in January 2010 with a TAC of 7000 t. The fisheries for anchovy are targeted by purse-seiners and pelagic trawlers. The Spanish and French fleets fishing for anchovy in Subarea VIII are spatially and temporally quite well separated. The Spanish fleet (purse-seine fleet) operates mainly in Divisions VIIIc and VIIIb in spring, while the French fleet (mainly pelagic trawlers) operates in Division VIIIa in summer and autumn and in Division VIIIb in winter and summer. A small fleet of French purse-seiners operates in the south of the Bay of Biscay (VIIIb) in spring and in the north (VIIIa) during the autumn. An overview of the history of the fishery until the mid-nineties and its spatial behaviour is found in Junquera (1986) and Uriarte *et al.* (1996) and for more recent perspective see ICES (2007, 2008) or STECF (2008) for the international fishery, Uriarte *et al.* (2008); Villamor *et al.* (2008), for the Spanish fishery and Duhamel (2004) and Vermard *et al.* (2008) for the French pelagic trawler. According to information provided by the SWWRAC in 2009 during the closure of the fishery the fleet size operating on anchovy decreased and the fleets redeployed their effort towards other small pelagic species (57%) and tuna (29%).

A.3. Ecosystem aspects

Anchovy is a prey species for other pelagic and demersal species in the Bay of Biscay, and also for cetaceans and birds (Goñi *et al*., 2011a,b; López-López *et al*., 2012). In addition to predator interactions on adults, in recent years major attention is being paid to the role that intraguild predation may have in affecting the survival of early life stages (Irigoien and Ross, 2011), and for this anchovy the potential influence of sardine predating on anchovy eggs has been evidenced (Bachiller *et al*., submitted).

The recruitment depends strongly on environmental factors. Recently ICES WGSPEC (ICES, 2012) has reviewed the role that environmental factors may have on determining the success of recruitment. Two environmental recruitment indices have been considered during the last ten years: i) Borja's *et al.* (1998) index, which is an upwelling index, and ii) Allain's *et al.* (2001) index, which is a combination of upwelling and stratification breakdown. Allain's model was reviewed by Huret and Petitgas (WD 2007, ICES 2008) including a) the previous "upwelling" index, plus a new "stratification" index according to a new hydrodynamic model and b) an adult spatial indicator. The role of the Eastern Atlantic pattern in relation to the Upwelling index and the recruitment of anchovy have also been recently pointed out (Borja *et al.*, 2008). Other approaches based on coupling spawning habitat with hydrodynamic and production models are being tried for this anchovy population with promising results (Allain *et al*., 2007). From the latter studies the issue of much drifting (induced by the Upwelling) of the anchovy eggs and larval out of the shelf is controversial among scientists (Borja *et al*., 1996; 1998; Uriarte, 2001; Allain *et al*., 2001; 2007; Irigoien, 2007; 2008).

Recent research for identifying and monitoring limiting factors of anchovy recruitment in the Bay of Biscay was made by Petitgas (2011). Indices of physical features were estimated (river plumes, gyres, stratification, fronts) as well as indices of larval dispersal, primary production and temperature. Indices of spawning aggregations derived from fisheries survey data were also estimated. Results showed that the larval period was where many indices responded, confirming that it is a critical period. The limiting factors changed across the series, confirming the multiple nature of the determinism of recruitment.

Fernandes *et al*. (2010) presents an alternative to attempt to relate environmental indices with recruitment by means of linear models. They use machine-learning techniques to obtain the probability of having a recruitment discretized into low, medium and high classes depending on environmental variables. The proposed methodology consists of performing supervised predictors discretization, carrying out supervised predictors selection and learning a 'naive Bayes' classifier. The approach can be applied to a dataset where the values of the recruitment have been discretized by the end-user, or the recruitment discretization can be part of the proposed model-building process in a bootstrap scheme. Environmental variables seem to explain a significant part of the observed variability of the small pelagics but not more than 50% of it (at least from the available indicators), so that there is space for looking for other supplementary variables driving recruitment for these species. The significance and reliability of all these indices is considered still insufficient for their consideration alone in the provision of management advice. But they are considered valuable information accompanying the forecasts given from recruitment surveys such as JUVENA. It is certainly useful their consideration for further improvements.

B. Data

B.1. Commercial catches

Annual landings are available since 1940. Discards are not measured and hence not included in the assessment, but nowadays they are considered not relevant for the two fleets. In the past (late eighties and early nineties for the French Pelagic trawlers and sixties and seventies for the Spanish Purse seine fleet) they seemed to be more relevant (according to disputes among fishermen), but were never quantified.

B.2. Biological

- Catches-at-length and catches-at-age are known since 1984 for Spain and since 1987 for France. They are obtained by applying to the monthly Length distributions half year or quarterly ALKs (and when possible monthly ALKs, as for the Spanish fishery in spring). Biological sampling of the catches has been generally sufficient, except for 2000 and 2001, when an increase of the sampling effort seemed useful to have a better knowledge of the age structure of the catches during the second semester in the North of the Bay of Biscay. Complete age composition and mean weight-at-age on half year basis, were reported in ICES.
- Age reading is considered accurate.

  The most recent cross reading exchanges and workshop took place in 2009 WKARA (ICES CM 2009/ACOM:43). The overall level of agreement and precision in anchovy age reading determinations seemed to be satisfactory: Most of the anchovy otoliths were well classified by most of the readers during the exchange (with an average agreement of 88.8% and a CV of 12.9%). CV was minimum at age 0 and increased slightly with age while the percentage of agreement decreased with age (with Percentage of agreement with the modal ages of 100%, 83%, 91% and 63% respective to ages 0, 1, 2 and 3). The most expert readers who are in charge of the largest fraction of the international catches showed higher agreements than the rest of readers.

- In former workshops between Spain and France which took place in 2005 and 2006 respectively (Uriarte *et al.*, 2006 and 2007) the overall level of agreement and precision in anchovy age reading determinations was also satisfactory. Most of the anchovy otoliths were well classified by most of the readers during the 2006 workshop (with an average agreement of 92.7% and a CV of 9.2%). CVs were on average smaller than 15% for any age, although individual CVs for ages or readers might be 30–35%. Anchovies are mature at their 1st year of life.
- Growth in weight and length are well known from surveys and from the monitoring of the fishery (Uriarte *et al.*, 1996).
- Natural mortality is fixed at 0.8 for age 1 and at 1.2 for older individuals. This parameter is considered to vary between years, but it is assumed to be constant for the assessment of the stock.
- In the CBBM assessment model the parameters G_1 and G_{2+} representing the annual intrinsic growth of the population by age class are assumed constant along years and are estimated based on the weight-at-age data.

B.3. Surveys

The population is monitored by the two annual surveys carried out in spring on the spawning stock, namely, the Daily Egg Production Method (since 1987 with a gap in 1993) (Santiago and Sanz, 1992; Motos *et al.*, 2005; Santos *et al.*, 2011) and the Acoustics surveys (regularly since 1989, although surveys were also conducted in 1983, 1984 and some in the seventies) (Massé, 1988; 1994; 1996). Both surveys provide spawning biomass (this equals total stock biomass since all anchovies are mature in spring) and population-at-age estimates. The surveys have shown pronounced interannual variability of biomass according to the pulse of recruitments, since one year old anchovies can conform up to more than 75% of the spawning population. Spawning area and biomass are positive and closely related, revealing expansion of the area occupied by the population when SSB increases (Uriarte *et al.*, 1996; Somarakis *et al.*, 2004).

The spring surveys provide population estimates by the middle of the year, when about half of the annual catches have been already taken; and provide very little information about the anchovy population in the next year, since the bulk of it will consist of one year old anchovies being born at the time the surveys take place. Since 2003 an autumn acoustic survey (JUVENA) is conducted yearly. The main objective of this survey is estimating the anchovy juvenile abundance in order to forecast the strength of the recruitment that will enter the fishery the next year.

B.3.1 Anchovy Daily Egg Production Method

B.3.1.1 The DEPM model

The anchovy spawning–stock biomass estimate is derived according to Parker (1980) and Stauffer and Picquelle (1980) from the ratio between daily production of eggs in the sea and the daily specific fecundity of the adult population:

$$SSB = {}^{P_{tot}}\!\big/_{DF} = \frac{P_0 \cdot A+}{k \cdot R \cdot F \cdot S/W}$$ Equation B.3.1.1

Where,

SSB = Spawning–stock biomass in metric tons

P_{tot} = Total daily egg production in the sampled area

P_0 = daily egg production per surface unit in the sampled area

A+ = Spawning area, in sampling units

DF = Daily specific fecundity. $DF = \frac{k \cdot R \cdot F \cdot S}{W_f}$ Equation B.3.1.2

W_f = Average weight of mature females in grams,

R = Sex ratio, fraction of population that are mature females, by weight.

F = Batch fecundity, numbers of eggs spawned per mature females per batch

S = Fraction of mature females spawning per day

k = Conversion factor from gram to metric tons (10^6)

An estimate of an approximate variance and bias for the biomass estimator derived using the *delta* method (Seber, 1982, *in* Parker 1985.) was also developed by the latter authors.

Population estimates of numbers-at-age are derived as follows:

$$N_a = N \cdot E_a = \frac{SSB}{W_t} \cdot E_a$$ Equation B.3.1.3

Where,

N_a = Population estimate of numbers-at-age *a*.

N = Total spawning–stock estimate in numbers. $N = \frac{SSB}{W_t}$

SSB = spawning–stock biomass estimate.

W_t = average weight of anchovies in the population.

E_a = Relative frequency (in numbers) of age *a* in the population.

W_t and E_a are obtained from the average of the mean weight and the percentages by ages across the anchovy samples from the survey (see the adult parameter section below).

Variance estimate of the anchovy stock in numbers-at-age and total is derived applying the delta method.

B.3.1.2 Collection of plankton samples

Every year the area covered to collect the plankton samples is the southeast of the Bay of Biscay which corresponds to the main spawning area and spawning season of anchovy.

Predetermined distribution of stations is shown in Figure B.3.1.2.1. The strategy of egg sampling is as follow: a systematic central sampling scheme with random origin and sampling intensity depending on the egg abundance found (Motos, 1994). Stations are located every three miles along 15-mile-apart transects perpendicular to the coast. The sampling strategy is adaptive. When the egg abundances found are relatively high, additional transects separated by 7.5 nm are completed.

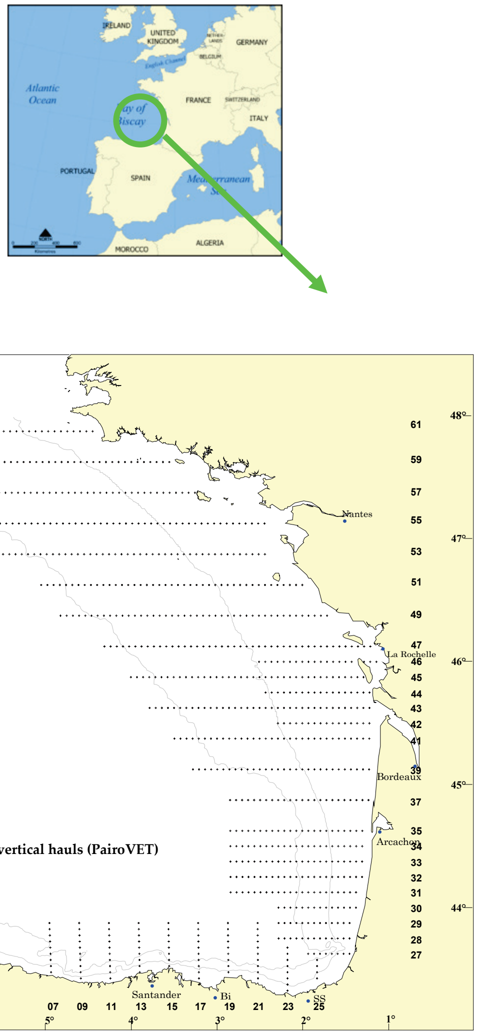

Figure B.3.1.2.1. Predetermined stations of the vertical hauls (PairoVET) that could be performed during the survey.

At each station a vertical plankton haul is performed using a PairoVET net (Pair of Vertical Egg Tow, Smith *et al.*, 1985 in Lasker, 1985) with a net mesh size of 150 µm for a total retention of the anchovy eggs under all likely conditions. The net is lowered to a maximum depth of 100 m or 5 m above the bottom in shallower waters. After allowing ten seconds at the maximum depth for stabilisation, the net is retrieved to the surface at a speed of 1 m s-1. A 45 kg depressor is used to allow for correctly deploying the net. "G.O. 2030" flowmeters are used to detect sequential clogging of the net during a series of tows.

Immediately after the haul, the net is washed and the samples obtained are fixed in formaldehyde 4% buffered with sodium tetra borate in seawater. After six hours of fixing, anchovy, sardine and other eggs species are identified, sorted out and counted on board. Afterwards, in the laboratory, a percentage of the samples are checked to assess the quality of the sorting made at sea. According to that, a portion of the samples are sorted again to ensure no eggs were left in the sample. In the laboratory, anchovy eggs are classified into morphological stages (Moser and Alshtrom, 1985).

The Continuous Underway Fish Egg Sampler (CUFES, Checkley *et al*., 1997) is used to record the eggs found at 3 m depth with a net mesh size of 350 µm. The samples obtained are immediately checked under the microscope so that the presence/absence of anchovy eggs is detected in real time. When anchovy eggs are not found in six consecutive CUFES samples in the oceanic area transect is abandoned. The CUFES system has a CTD to record simultaneously temperature and salinity at 3 m depth, a flowmeter to measure the volume of the filtered water, a fluorimeter and a GPS (Geographical Position System) to provide sampling position and time. All these data are registered at real time using the integrated EDAS (Environmental Data Acquisition System) with custom software.

During the survey, the anchovy, sardine and other eggs are recorded per PairoVET station and the area where anchovy eggs occurred is quantified. The spawning area is delimited with the outer zero anchovy egg stations. It contains some inner zero egg stations embedded on it (Picquelle and Stauffer, 1985). Following the systematic central sampling scheme (Cochran, 1977) each station is located in the centre of a rectangle. Egg abundance found at a particular station is assumed to represent the abundance in the whole rectangle. The area represented by each station is measured. A standard station has a surface of 45 squared nautical miles (154 km^2) = 3 (distance between two consecutive stations) x 15 (distance between two consecutive transects) nautical miles. Since sampling is adaptive, station area changed according to sampling intensity and the cut of the coast.

Sample depth, temperature, salinity and fluorescence profiles are obtained in every station using a CTD RBR-XR420 coupled to the PairoVET. In addition, surface temperature and salinity are recorded in each station with a manual termosalinometer WTW LF197. Moreover current data are obtained all along the survey with an ADCP (Acoustic Doppler Current Profiles). In some point determinate previously to the survey, water is filtered from the surface to obtain chlorophyll samples to calibrate the chlorophyll data.

The historical maps of anchovy egg distribution obtained with PairoVET are shown in Figure B.3.1.2.2.

B.3.1.3 Collection of adult samples

In 1987 and 1988 the samples were obtained from commercial purse-seines and the adult sampling was opportunistic. From years 1989 to 2005 the adult samples were obtained both from commercial purse-seines and a research vessel with pelagic trawl so the adult sampling was both opportunistic and directed. Since 2006 the samples are obtained from a research vessel with pelagic trawl. Samples from the purse-seines were not available due to the closure of the fishery. Since the reopening of the fisheries in March 2010 the commercial purse-seines are providing again samples for the analysis apart from the ones obtained from the research vessel.

The research vessel pelagic trawler covers the same area as the plankton vessel. When the plankton vessel encountered areas with anchovy eggs, the pelagic trawler is directed to those areas to fish. In each haul 100 individuals of each species are measured. Immediately after fishing, anchovy is sorted from the bulk of the catch and a sample of two Kg is selected at random. A minimum of one kg or 60 anchovies are weighted, measured and sexed and from the mature females the gonads of 25 non-hydrated females (NHF) are preserved. If the target of 25 NHF is not completed ten more anchovies are taken at random and process in the same manner. Sampling is stopped when 120 anchovies have to be sexed to achieve the target of 25 NHF. Otoliths are extracted on board and read in the laboratory to obtain the age composition per sample. In case samples are obtained from the purse-seines, a sample of two kg is selected from the fishing and is directly kept in 4% formaldehyde. Afterwards, in the laboratory the samples are process in the same manner as explained above.

B.3.1.4 Total daily egg production estimates

When all the anchovy eggs are sorted and staged, it is possible to estimate the total daily egg production (P_{tot}). This is calculated as the product between the daily egg production (P_0) and the spawning area (SA):

$$P_{tot} = P_0 \, SA \qquad (1)$$

A standard sampling station represents a surface of 45 nm^2 (i.e. 154 km^2). Since the sampling was adaptive, area per station changes according to the sampling intensity and the cut of the coast. The total area is calculated as the sum of the area represented by each station. The spawning area (SA) is delimited with the outer zero anchovy egg stations but it can contain some inner zero stations embedded. The spawning area is computed as the sum of the area represented by the stations within the spawning area.

The daily egg production per area unit (P_0) was estimated together with the daily mortality rate (Z) from a general exponential decay mortality model of the form:

$$P_{i,j} = P_0 \exp\left(-Z \, a_{i,j}\right), \qquad (2)$$

where Pi,j and ai,j denote respectively the number of eggs per unit area in cohort j in station i and their corresponding mean age. Let the density of eggs in cohort j in station i, Pi,j, be the ratio between the number of eggs Ni,j and the effective sea area sampled Ri (i.e. $P_{i,j} = N_{i,j} / R_i$). The model was written as a generalised linear model (GLM, McCullagh and Nelder, 1989; ICES, 2004) with logarithmic link function:

$$\log\left(E[N_{i,j}]\right) = \log(R_i) + \log\left(P_0\right) - Z \, a_{i,j} \;, \qquad (3)$$

where the number of eggs of daily cohort j in station i (N_{ij}) was assumed to follow a negative binomial distribution. The logarithm of the effective sea surface area sampled ($\log(R_i)$) was an offset accounting for differences in the sea surface area sampled and the logarithm of the daily egg production $\log(P_0)$ and the daily mortality Z rates were the parameters to be estimated.

The eggs collected at sea and sorted into morphological stages had to be transformed into daily cohort frequencies and their mean age calculated in order to fit the above model. For that purpose the Bayesian ageing method described in ICES (2004), Stratoudakis *et al.*, (2006) and Bernal *et al.*, (2011) was used. This ageing method is based on the probability density function (pdf) of the age of an egg *f(age | stage, temp)*, which is constructed as:

$$f(age \mid stage, temp) \propto f(stage \mid age, temp) \, f(age) \qquad (4)$$

The first term f(stage | age, temp) is the pdf of stages given age and temperature. It represents the temperature dependent egg development, which is obtained by fitting a multinomial model like extended continuation ratio models (Agresti, 1990) to data from temperature dependent incubation experiments (Ibaibarriaga *et al*., 2007; Bernal *et al*., 2008). The second term is the prior distribution of age. *A priori* the probability of an egg that was sampled at time τ of having an age is the product of the probability of an egg being spawned at time τ - age and the probability of that egg surviving since then (exp(-Z age)):

$$f(age) \propto f(spawn = \tau - age)\exp(-Z\ age) \tag{5}$$

The pdf of spawning time f(spawn= τ - age) allows refining the ageing process for species with spawning synchronicity that spawn at approximately certain times of the day (Lo, 1985a; Bernal *et al*., 2001). Anchovy spawning time was assumed to be normally distributed with mean at 23:00 h GMT and standard deviation of 1.25 (ICES, 2004). The peak of the spawning time was also used to define the age limits for each daily cohort (spawning time peak plus and minus 12 hours). Details on how the number of eggs in each cohort and the corresponding mean age are computed from the pdf of age are given in Bernal *et al*. (2011). The incubation temperature considered was the one obtained from the CTD at 10 m in the way up.

Given that this ageing process depends on the daily mortality rate which is unknown, an iterative algorithm in which the ageing and the model fitting are repeated until convergence of the Z estimates was used (Bernal *et al*., 2001; ICES, 2004; Stratoudakis *et al*., 2006). The procedure is as follows:

Step 1. Assume an initial mortality rate value;

Step 2. Using the current estimates of mortality calculate the daily cohort frequencies and their mean age;

Step 3. Fit the GLM and estimate the daily egg production and mortality rates. Update the mortality rate estimate;

Step 4. Repeat steps 1–3 until the estimate of mortality converged (i.e. the difference between the old and updated mortality estimates was smaller than 0.0001).

Incomplete cohorts, either because the bulk of spawning for the day was not over at the time of sampling, or because the cohort was so old that its constituent eggs had started to hatch in substantial numbers, were removed in order to avoid any possible bias. At each station, younger cohorts were dropped if they were sampled before twice the spawning peak width after the spawning peak and older cohorts were dropped if their mean age plus twice the spawning peak width was over the critical age at which less than 99% eggs were expected to be still unhatched. In addition, cohorts in which hatching has started are excluded: Upper limit is set at the age in which 99% of the eggs are unhatched, having developed at the 50 quantile of the incubation temperature.

Once the final model estimates were obtained the coefficient of variation of P_0 was calculated from the standard error of the model intercept (log(P0)) (Seber, 1982) and the coefficient of variation of Z was obtained directly from the model estimates.

The analysis was conducted in R (www.r-project.org). The "MASS" library was used for fitting the GLM with negative binomial distribution and the "egg" library (http://sourceforge.net/projects/ichthyoanalysis/) for the ageing and the iterative algorithm.

B3.1.5 Adult parameters and daily fecundity estimates

The daily fecundity (DF) estimate for the WGHANSA in June is obtained following the equation B.3.1.2. The adult parameters sex ratio (R), Batch fecundity (F) and average weight of mature female (W_f) are estimate in June from the adults obtained during the survey as explained below. The Spawning frequency (S) is taken in June as the mean of the historical series because histologic processing is required for this parameter and this takes longer than 15 days (time lapsed from the end of the survey until the evaluation meeting in June). Afterwards in the ICES WGACEGG in November the complete DEPM with all the adult parameters, including S estimates, is presented and approved. This occurred since 2005 when the advice started demanding SSB estimates in June.

In case of not having time enough after the survey in a particular year as to process the adult parameters for the June assessment then the mean of past Daly Fecundity estimates would be preliminarily borrowed from the historical series.

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Ordinary processing of the adult parameters: From the whole set of adult samples gathered during the survey, a subset is chosen for final processing with the criterion of collection within ±5 days of the egg sampling in the same particular area. In the last years the samples were collected within the same day as the egg sampling. Batch fecundity (F), spawning fraction (S), average female weight (W) and sex ratio (R) are estimated as follows:

Sex Ratio (R): Given the large variability among samples of the sex ratio and taking into account that for most of the years when the DEPM has been applied to this population the final estimate has come out to be not significantly different from 50% for each sex (in numbers), since 1994 the proportion of mature females per sample is being assumed to be equal to 1:1 in numbers. This leads to adopt as R the value of the average sample ratio between the average female weight and the sum of the average female and male weights of the anchovies in each of the samples.

Total weight of hydrated females is corrected for the increase of weight due to hydration. Data on gonad-free-weight (Wgf) and correspondent total weight (W) of non-hydrated females is fitted by a linear regression model. Gonad-free-weight of hydrated anchovies is then transformed to total weight by applying the following equation:

$$W = -a + b * W_{gf}$$

For the **Batch fecundity (F)** estimates i.e. number of eggs laid per batch and female, the hydrated egg method was followed (Hunter *et al.*, 1985). The number of hydrated oocytes in gonads of a set of hydrated females is counted. This number is deduced from a subsampling of the hydrated ovary: Three pieces of approximately 50 mg are removed from different parts of each ovary, weighted with precision of 0.1 mg and the number of hydrated oocytes counted. Sanz and Uriarte (1989) showed that three tissue samples per ovary are adequate to get good precision in the final batch fecundity estimate and the location of subsamples within the ovary do not affect it. Finally the number of hydrated oocytes in the subsample is raised to the total gonad of the female according to the ratio between the weights of the gonad and the weight subsampled.

A linear regression between female weight and batch fecundity is established for the subset of hydrated females and used to calculate the batch fecundity of all mature females. The average of the batch fecundity estimates for the females of each sample as derived from the gonad free weight; eggs per batch relationship is then used as the sample estimate of batch fecundity.

Moreover, an analysis is conducted to verify if there are differences in the batch fecundity between different strata if strata are defined to estimate SSB.

To estimate **Spawning Frequency (S)**, i.e. the proportion of females spawning per day: Spawning frequency estimates are obtained applying the new classification for oocyte and POFs stage of Alday *et al*. (2008) and the procedures described in Uriarte *et al*. (2012). The degeneration of postovulatory follicles (POFs) in time at different temperatures was studied for the Bay of Biscay anchovy by Alday *et al*. (2008). For this purpose a key of seven POF stages, solely defined on the basis of their histological degeneration characteristics, was applied (Alday *et al*., 2008; 2010). The novelty of this procedure is that it separates staging of POFs from their ageing process. The ovaries, taken from several captivity experiments and field samples, were classified in this way. There was close agreement in the succession of POF stages after spawning between the experiment and the field samples. The first four stages of POF occurred in less than 24 h, and by the end of the first day the POFs were mainly in Stage V. Stages VI and VII showed their highest occurrence during the first and second half of the second day after spawning, respectively. Full reabsorption of POFs was achieved in 55–60 h. For the range of temperatures examined (13–19°C), little effect of temperature on the degeneration of POF was noticed.

The procedure to assign mature females to spawning classes was improved by incorporating all the knowledge on oocyte maturation and degeneration of POFs in a matrix system which defines the probabilities of females with those histological indicators belonging to pre- or post-spawning cohort according to the time of capture (Uriarte *et al*., 2012).

Finally, the selected estimator is the mean of S (day 0) and S (day 1). Corrections of sample estimates +/-five hours around peak spawning time (23:00 hours) were applied according to the formulas in Uriarte *et al*. (op. cit.) for an average S of 0.39.

For the years with S estimates which could not be reviewed by the time of WKPELA 2013 (2006, 1989, 1988 and 1987), but have their own estimates of the other reproductive parameters, the average of the historical series (1990–2012) of new S was considered. For the years which did not have any adult reproductive parameters, 1996, 1999 and 2000, the average Daily Fecundity (DF) estimate across the historical series (1990–20012) was adopted (of about 98.5 eggs gram-1 day-1).

Mean and variance of the adult parameters are estimated following equations for cluster sampling (as suggested by Picquelle and Stauffer, 1985):

$$Y = \frac{\sum_{i=1}^{n} M_i \, y_i}{\sum_{i=1}^{n} M_i} \qquad \text{Equation 6}$$

$$Var(Y) = \frac{\sum_{i=1}^{n} M_i^2 (y_i - Y)^2}{\overline{M}^2 n(n-1)}$$ Equation 7

Where,

Y_i is an estimate of whatever adult parameter from sample i and M_i is the size of the cluster corresponding to sample i. occasionally a station produced a very small catch, resulting in a small subsample size. To reflect the actual size of the station and its lower reliability, small samples were given less weight in the estimate. For the estimation of W, F and S, a weighting factor was used, which equalled to one when the number of mature females in station i (M_i) was 20 or greater and it equalled to $M_i/20$ otherwise. In the case of R when the total weight of the sample was less than 800 g then the weighting factor was equal to total weight of the sample divided by 800 g, otherwise it was set equal to one. In summary for the estimation of the parameters of the Daily Fecundity we are using a threshold-weighting factor (TWF) under the assumption of homogeneous fecundity parameters within each stratum.

B.3.1.6 SSB estimates

In WGHANSA during June the spawning–stock biomass (SSB) is preliminary estimated, following equation B.3.1.1, as the ratio between the total egg production (P_{tot}) and Daily Fecundity (DF) (the latter estimated as the equation 2 with the exception of the S parameter that is obtained as the mean of the historical series). The SSB variance is computed using the Delta method (Seber, 1982):

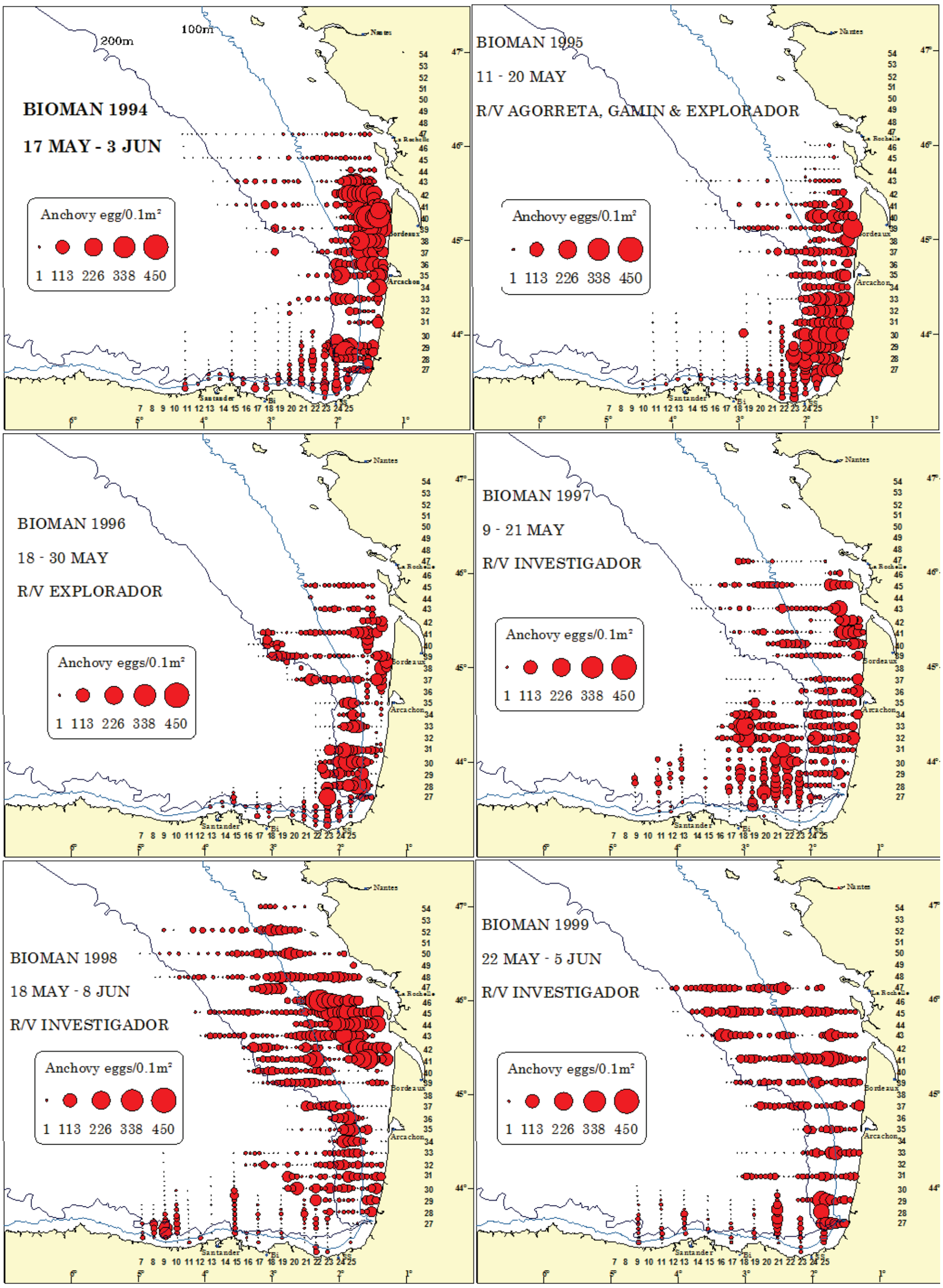
$$V\hat{a}r[SSB] = \frac{V\hat{a}r[Ptot]}{DF^2} + \frac{P_{tot}^{\ 2} V\hat{a}r[DF]}{DF^4}$$

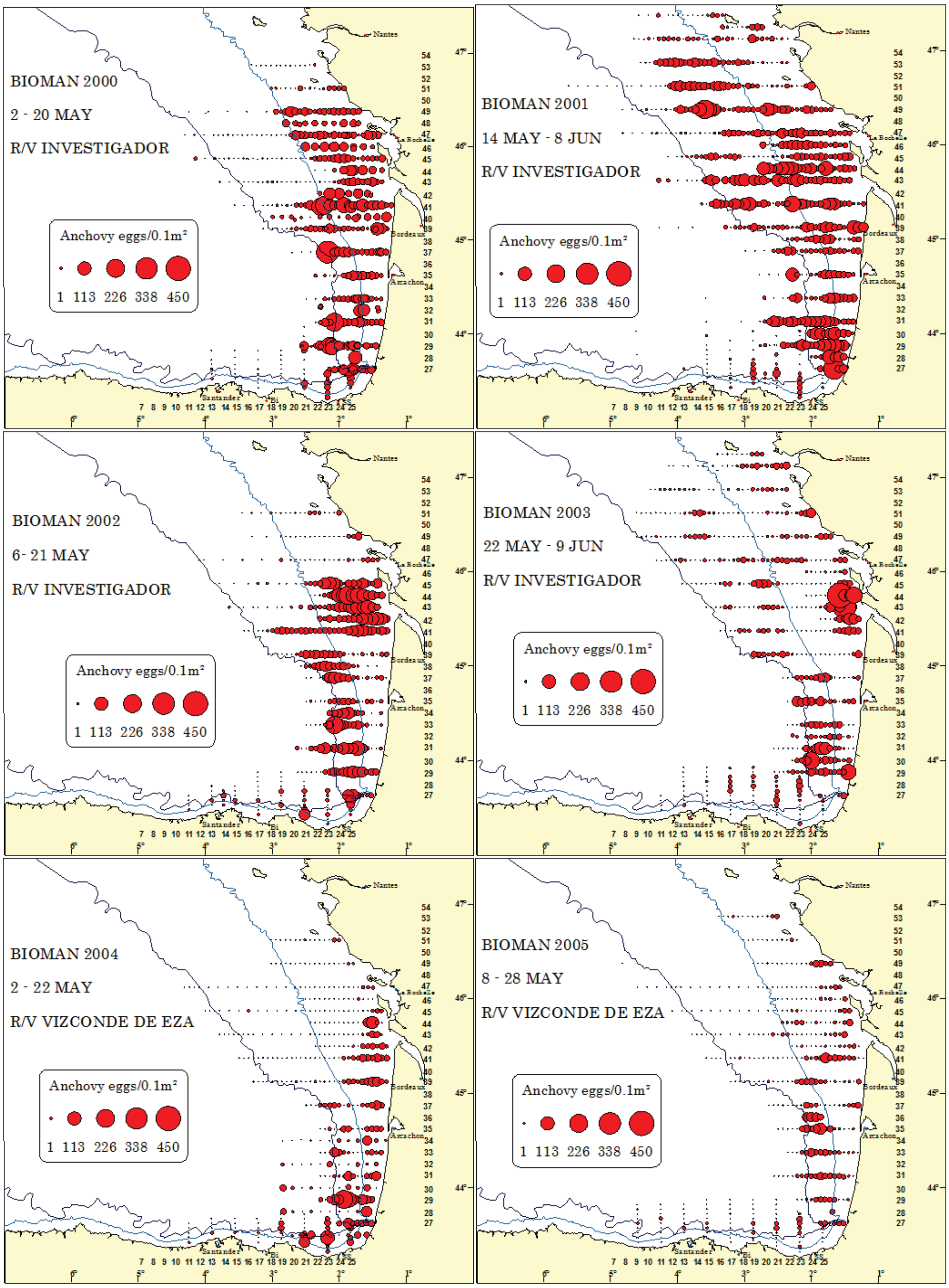
The definitive SSB estimate, following B.3.1.1, with all the adult parameters including the S estimate is presented and approved at WGACEGG during November.

B.3.1.7 Numbers-at-age

For the purposes of producing population-at-age estimates, the age readings based on otoliths from the adult samples collected are available. Estimates of anchovy mean weights and proportions-at-age in the adult population are computed as a weighted average of the mean weight and age composition per samples where the weights are proportional to the population (in numbers) in each stratum considered. These weighting factors are proportional to the egg abundance per stratum divided by the numbers of samples in the stratum and the mean weight of anchovy per sample. Weighting factors were allocated according to the relative egg abundance and to the amount of samples in the strata defined for the proposed of the estimation of the numbers-at-age. These strata are defined each year depending on the distribution of the adult samples i.e. size, weight, age and the distribution of the anchovy eggs.

Mean and variance of the adult parameters of the population in numbers-at-age and the population length distribution (total weight, proportion by ages and length distribution) are estimated following equations 6 and 7 for cluster sampling.


BIOMAN 1994
17 MAY - 3 JUN
Anchovy egg/0.1m²
1 113 226 338 450
BIOMAN 1995
11 - 20 MAY
R/V AGORRETA, GAMIN & EXPLORADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 1996
18 - 30 MAY
R/V EXPLORADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 1997
9 - 21 MAY
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 1998
18 MAY - 8 JUN
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 1999
22 MAY - 5 JUN
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450


BIOMAN 2000
2 - 20 MAY
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2001
14 MAY - 8 JUN
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2002
6- 21 MAY
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2003
22 MAY - 9 JUN
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2004
2 - 22 MAY
R/V VIZCONDE DE EZA
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2005
8 - 28 MAY
R/V VIZCONDE DE EZA
Anchovy eggs/0.1m²
1 113 226 338 450
Nantes
La Rochelle
Bordeaux
Arcachon
Santander
Bi

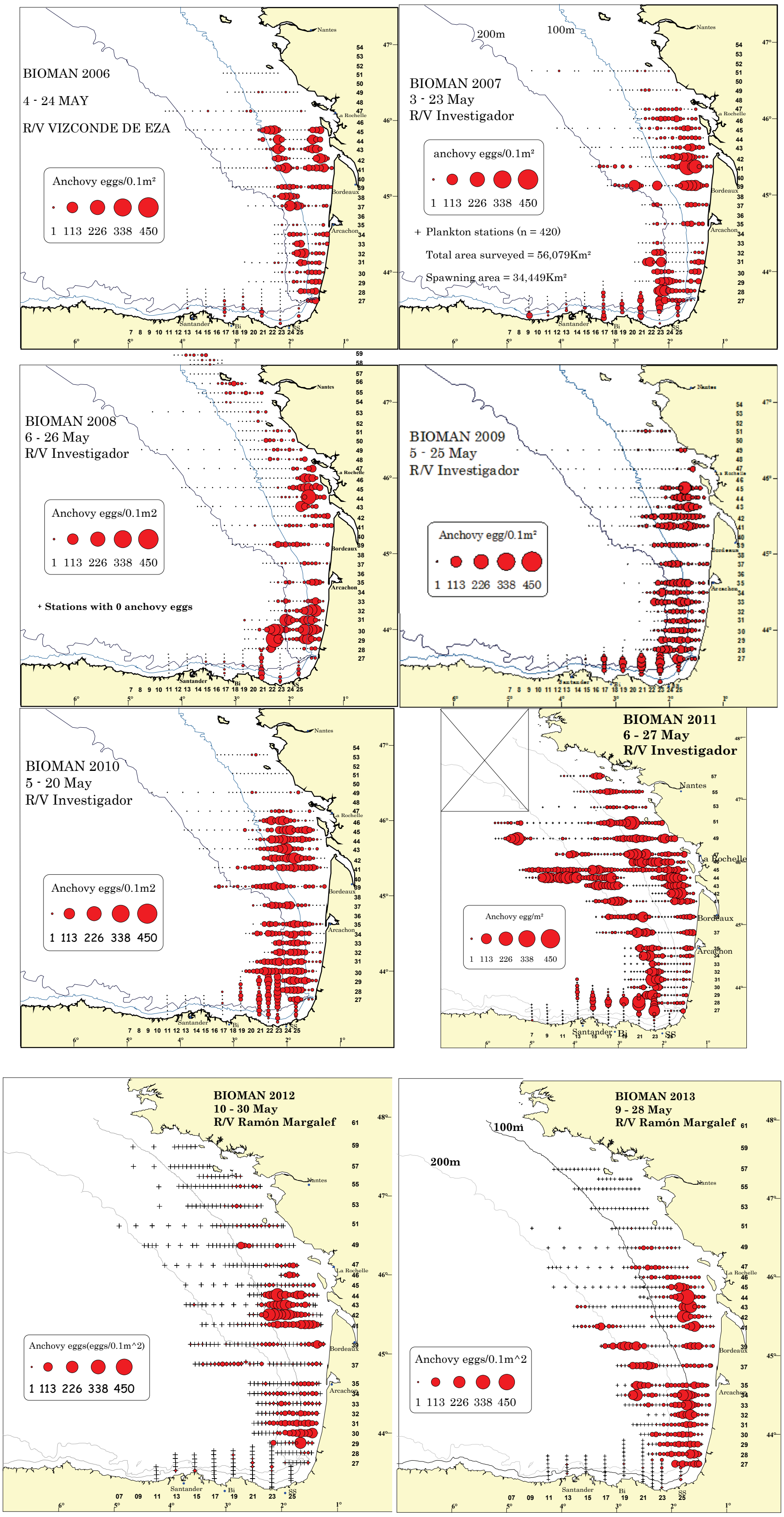


Figure B.3.1.2.2. Anchovy egg distribution from 1998 to 2013.The circles represent the anchovy egg abundance /0.1m² encountered in each plankton station.

B.3.2. Anchovy acoustic indices

Acoustic surveys are carried out every year in the Bay of Biscay in spring on board the French research vessel Thalassa. The objective of PELGAS surveys is to study the abundance and distribution of pelagic fish in the Bay of Biscay. The main target species is anchovy but it will be considered in a multispecific context as species located in the centre of ecosystem.

These surveys are connected with Ifremer programmes on data collection for monitoring and management of fisheries and ecosystemic approach for fisheries. This task is formally included in the first priorities defined by the Commission regulation EU N° 199/2008 of 06 November 2008 establishing the minimum and extended Community programmes for the collection of data in the fisheries sector and laying down detailed rules for the application of Council Regulation (EC) No 1543/2000. These surveys must be considered in the frame of the Ifremer fisheries ecology action "resources variability" which is the French contribution to the international Globec programme. It is planned with Spain (PELACUS) and Portugal (PELAGO) in order to have most of the potential area to be covered from Gibraltar to Brest with the same protocol for sampling strategy. Data are available for the ICES working groups WGHANSA, WGWIDE and WGACEGG.

B.3.2.1. Method and sampling strategy

In the frame of an ecosystemic approach, the pelagic ecosystem is characterized at each trophic level. In this objective, to assess an optimum horizontal and vertical description of the area, two types of actions are combined:

- Continuous acquisition by storing acoustic data from five different frequencies and pumping seawater under the surface in order to evaluate the number of fish eggs using a CUFES system (Continuous Under-water Fish Eggs Sampler); and
- Discrete sampling at stations (by trawls, plankton nets, CTD). Satellite imagery (temperature and sea colour) and modelisation are also used before and during the cruise to recognise the main physical and biological structures and to improve the sampling strategy.

Concurrently, a visual counting and identification of cetaceans and of birds (from board) is carried out in order to characterise the top predators of the pelagic ecosystem.

The strategy was the identical to previous surveys (2000 to 2009):

- Acoustic data were collected along systematic parallel transects perpendicular to the French coast (Figure B3.2.1.1). The length of the ESDU (Elementary Sampling Distance Unit) was one mile and the transects were uniformly spaced by 12 nautical miles covering the continental shelf from 20 m depth to the shelf break.
- Acoustic data were collected only during the day because of pelagic fish behaviour in this area. These species are usually dispersed very close to the surface during the night and so "disappear" in the blind layer for the echosounder between the surface and 8 m depth.

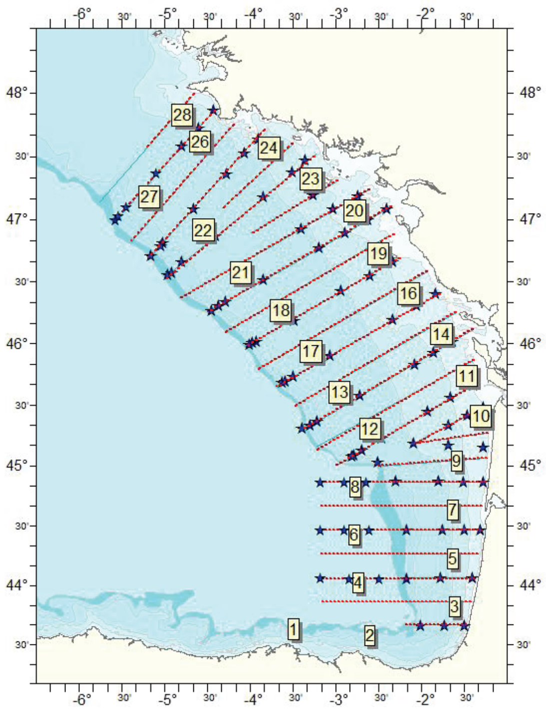


Figure B 3.2.1.1. Acoustic transects and stations during PELGAS surveys since 2000.

Two echosounders are usually used during surveys (SIMRAD EK60 for vertical echosounding and SIMRAD ME70 multibeam echosounder for a 3D approach since 2009). Energies and samples provided by split beam transducers (six frequencies EK60, 18, 38, 70, 120, 200 and 333 kHz), and multibeam echosounder were simultaneously visualised, stored using the MOVIES+ software and at the same standard HAC format.

The calibration method is the same that the one described for the previous years (see WD 2001) with a tungsten sphere hanged up 20 m below the transducer and is generally performed at anchorage in front of Machichaco Cap or in the Douarnenez Bay, at the west side of Brittany, in optimum meteorological conditions.

Acoustic data are collected by Thalassa along the totality of the daylight route from which about 2000 nautical miles on one way transect are usable for assessment. Fish are measured on board (for all species) and otoliths (for anchovy and sardine) are collected for age determinations.

B.3.2.2. Echoes scrutinizing

Most of the acoustic data along the transects are processed and scrutinised during the survey and are generally available one week after the end of the survey (Figure 2.2.1). Acoustic energies (Sa) are cleaned by sorting only fish energies (excluding bottom echoes, parasites, plankton, etc.) and classified into several categories of echotraces according to the year fish (species) structures.

Some categories are standard such as:

D1 – energies attributed to mackerel, horse mackerel, blue whiting, divers demersal fish, corresponding to cloudy schools or layers (sometimes small dispersed points) close to the bottom or of small drops in a 10 m height layer close to the bottom.

D2 – energies attributed to anchovy, sprat, sardine corresponding to the usual echotraces observed in this area since more than 15 years, constituted by schools well designed, mainly situated between the bottom and 50 meters above. These echoes are typical of clupeids in coastal areas and sometime more offshore.

D3 – energies attributed to blue whiting and myctophids offshore, just closed to the shelf break.

D4 – energies attributed to sardine, mackerel or anchovy corresponding to small and dense echoes, very close to the surface.

D6 – energies attributed to a mix, usually between 50 and 100 m depth when D1 and D2 were not separable.

Some particular categories are usually specifically designed according to several identifications during the survey (when Thalassa and/or commercial vessels hauls are available), such as:

D7 – energies attributed exclusively to sardine (big and very dense schools).

D5 – energies attributed to small horse mackerel only when they are gathered in very dense schools; this category is usually used for typical echoes which occur along particular surveys. In the case of 2010, it was used to gather energies which occurred all along the transects in the. northern platform where a continuous cover of mainly blue whiting was observed.

B.3.2.3. Data processing

The global area is split into several strata where coherent communities are observed (species associations) in order to minimise the variability due to the variable mixing of species. For each stratum, a mean energy is calculated for each type of echoes and the area measured. A mean haul for the strata is calculated to get the proportion of species into the strata. This is obtained by estimating the average of species proportions weighted by the energy surrounding haul positions. Energies are therefore converted into biomass by applying catch ratio, length distributions and TS relationships. The calculation procedure for biomass estimate and variance is described in Petitgas *et al.*, 2003.

The TS relationships used since 2000 are still the same and as following:

Sardine, anchovy and sprat:	TS = 20 Log L – 71.2
Horse mackerel:	TS = 20 Log L – 68.7
Blue whiting:	TS = 20 Log L – 67.0
Mackerel:	TS = 20 Log L – 86.0

The mean abundance per species in a stratum (tons m.n.$^{-2}$) is calculated as:

$$M_e(k)=\sum_D \bar{s}_A(D,k)\bar{X}_e(D,k)$$

and total biomass (tons) by: $B_e=\sum_k A(k)Me(k)$

where,

k: strata index

D: echo type

e: species

S_A: Average S_A (NASC) in the strata (m2/n.mi.2)

X_e: species proportion coefficient (weighted by energy around each haul) (tons m^{-2})

A: area of the strata (m.n.^{2})

Then variance estimate is:

$$Var.M_e(k)=\sum_D \bar{s}_A^{\,2}(D,k)Var[X_e(D,k)]/n.cha(k)+\bar{X}_e^{\,2}\,\mathrm{var}[s_A(D,k)]/n.esu(D,k)$$

$$Var.B_e=\sum_k A^2(k)Var.Me(k)$$

$$cv=\sqrt{Var.Be}/Be$$

At the end, density in numbers and biomass by length and age are calculated for each species in each ESDU according to the nearest haul length composition. These numbers and biomass are weighted by the biomass in each stratum and data are used for spatial distributions by length and age.

The detailed protocol for these surveys (strategy and processing) is described in Annex 6 of the WGACEGG Report in 2009.

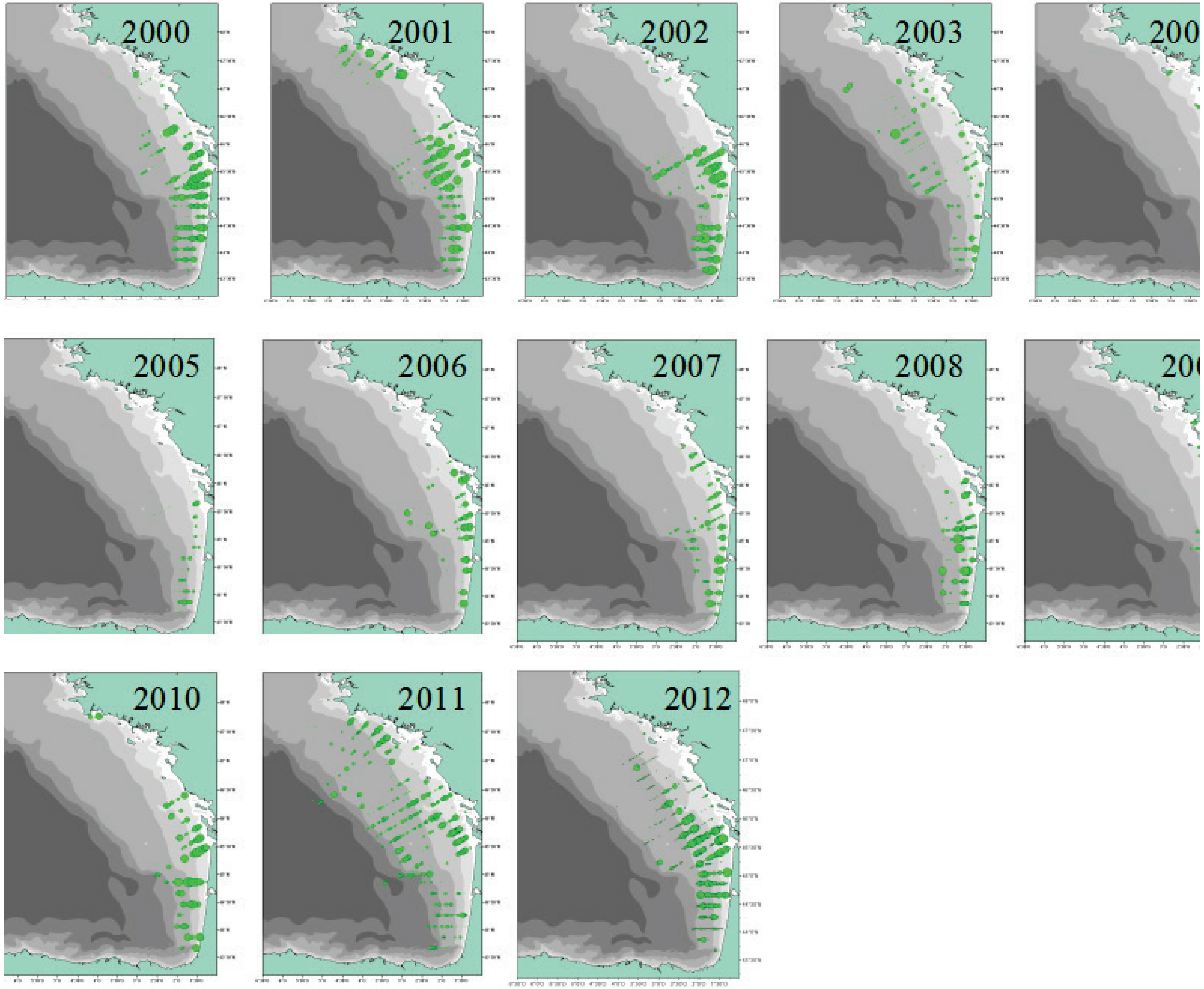


Figure B 3.2.1. Back-scattered energies (SA) registered for anchovy during PELGAS surveys since 2000.

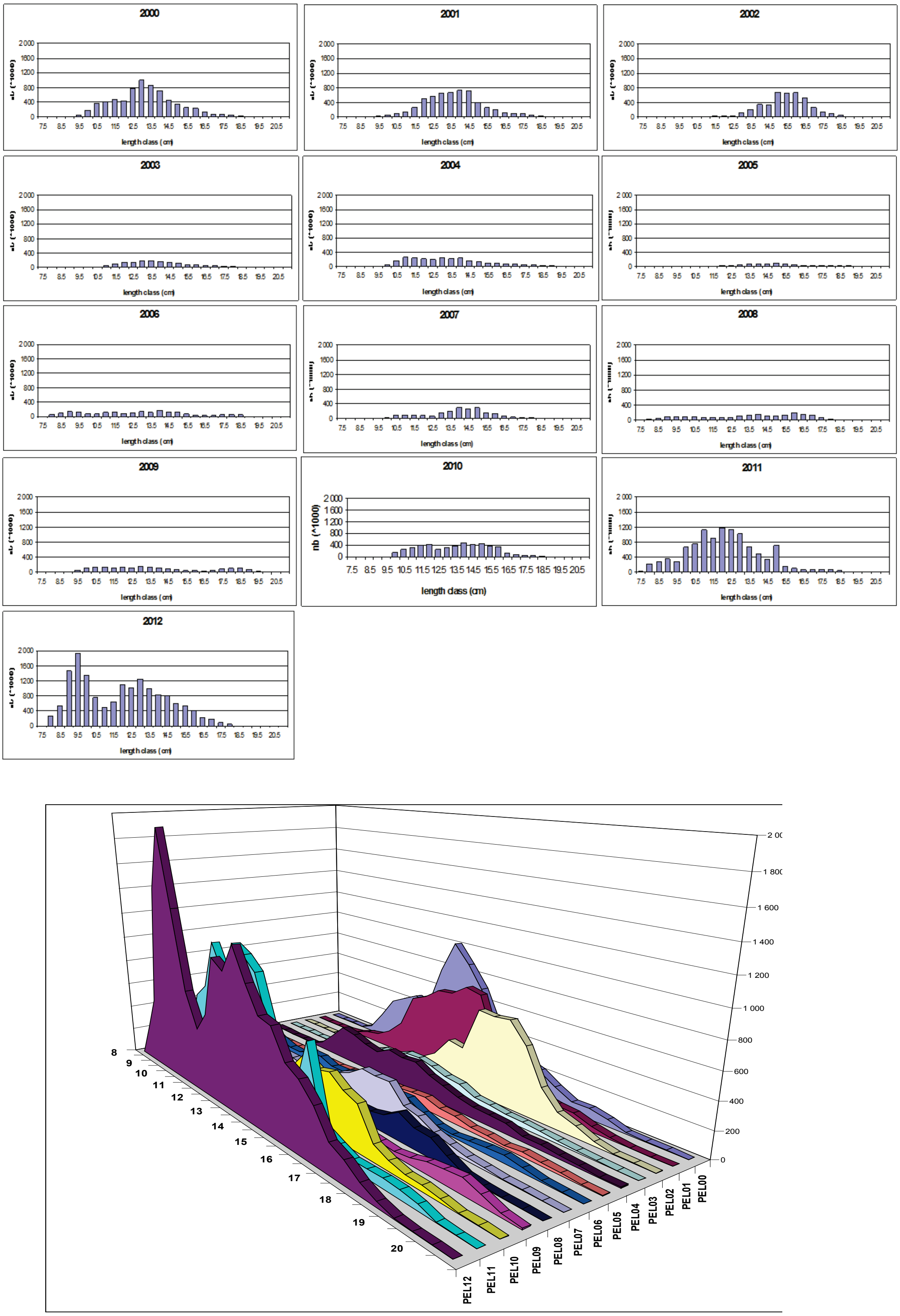


Figure B 3.2.2. Length composition of adults of anchovy as estimated by acoustics since 2000 during PELGAS surveys.

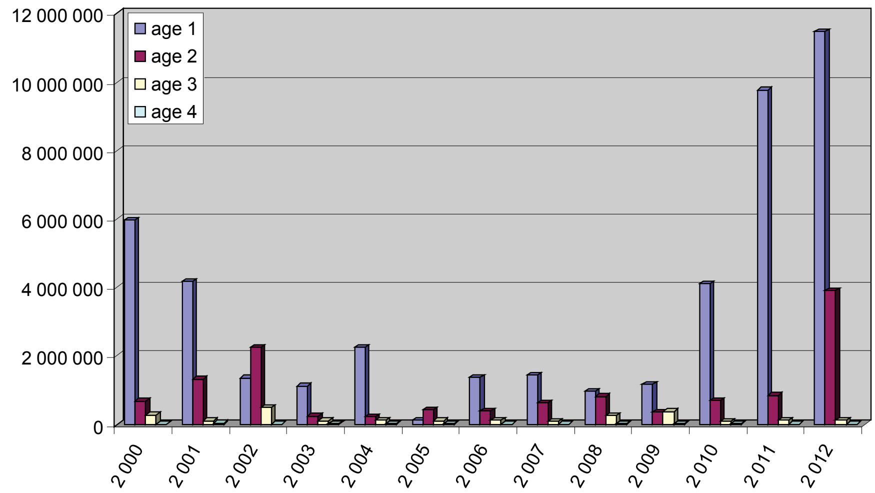


Figure B 3.2.3. Age composition of adults of anchovy as estimated by acoustics since 2000 during PELGAS surveys.

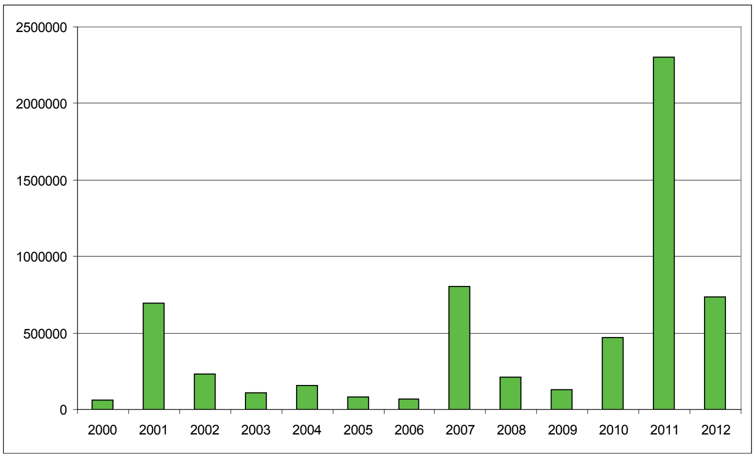


Figure B 3.2.4. Number of eggs observed during PELGAS surveys with CUFES from 2000 to 2010.

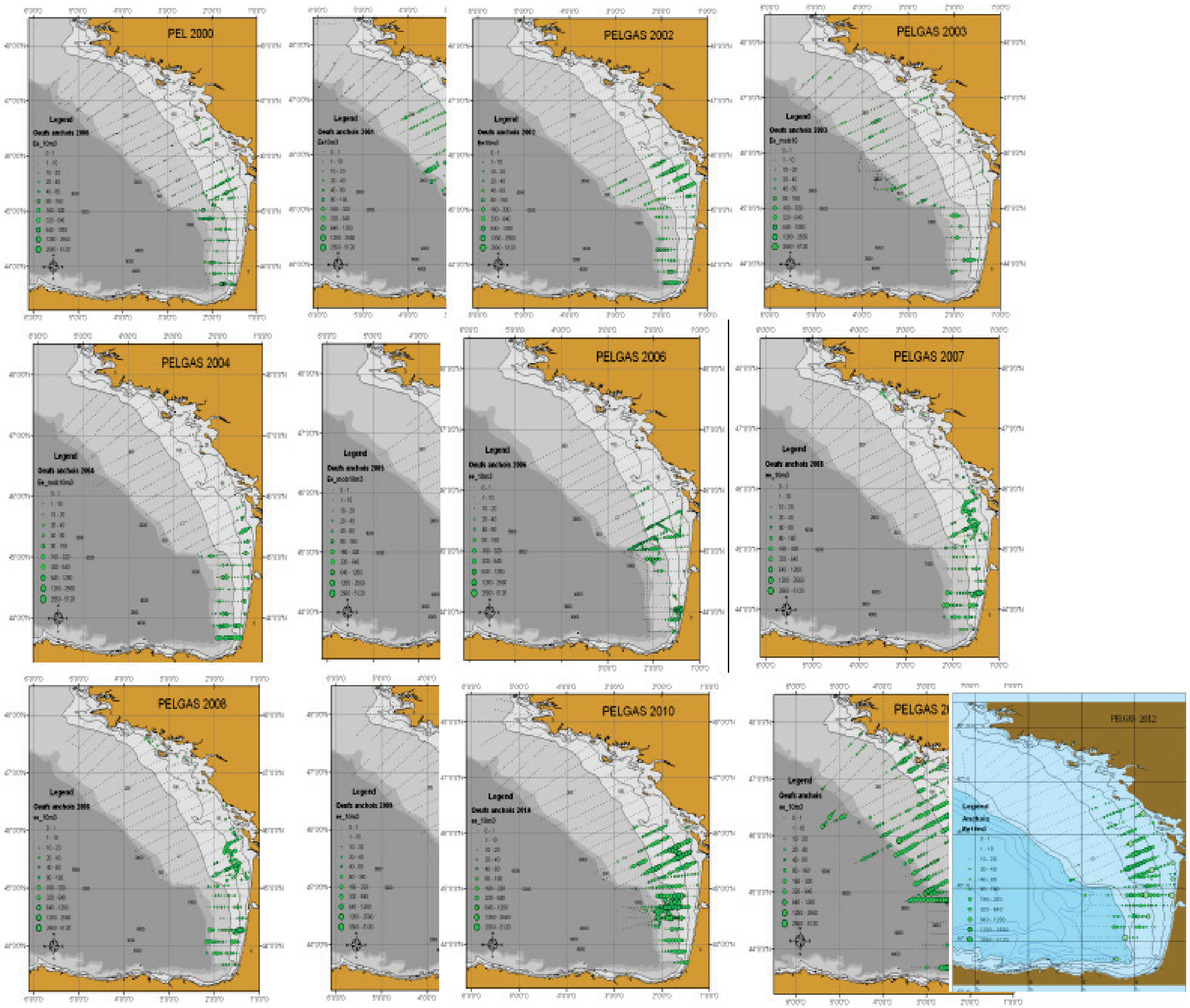


Figure B 3.2.5. Distribution of anchovy eggs observed with CUFES during PELGAS surveys from 2000 to 2012 (number for 10m³).

B.3.4 Autumn survey JUVENA on juvenile anchovy

Since year 2003, there is an acoustic survey to estimate abundance of juvenile anchovy (JUVENA) every September–October, with the long-term objective of forecasting the strength of the anchovy recruitment which will enter the fishery the next year (ICES 2008–2011 WGACEGG reports, Boyra *et al*. 2013). The survey was conducted by AZTI from 2003 to 2009, and is coordinated between AZTI and IEO since year 2010. The IEO conducted a parallel acoustic survey on anchovy, PELACUS10, from 2006 to 2009. Both surveys were merged in year 2010 in a joint JUVENA AZTI-IEO survey coordinated in ICES WGACEGG. This survey is expected to provide further insights on the recruitment process and additional knowledge on the biology and ecology of the juveniles.

The recruitment prediction capability of the survey has been tested by comparing the biomass estimates of juveniles and the next year's age-1 recruits for a wide range of recruitment values, and has been confirmed by the significant ($p<0.001$) positive correlations between them.

B.3.4.1 Sampling strategy

The JUVENA surveys were carried out annually between September and October in the Bay of Biscay. In these months the juveniles have grown enough to be visible to the echosounders (allowing the tuna fishing fleet to target them as live bait) and normally occupy large outer and off shelf areas in front of the Cantabric and west French coasts (Uriarte *et al*., 2001; Cort *et al*., 1976; Martin, 1976). Acoustic sampling was performed during the day because at this time of year juveniles usually aggregate in schools in the upper layers of the water column during the day, and can be distinguished from plankton structures (Uriarte *et al*., 2001; Cort *et al*., 1976). The sampling was carried out following a regular grid formed by transects arranged perpendicular to the coast (Figure B.3.4.1), spaced at 17.5 n.mi. (from 2003 to 2005) or 15 n.mi. (2006 onwards) to ensure their independence (Carrera *et al*., 2006). Sampling started in the Cantabrian Sea, going from west to east, and then moved to the north to cover the waters in front of the French coast. It is important to conduct the survey in the precise temporal window that extends from mid-August to mid-October, which is not too early, so juveniles have sufficiently grown and hence can be detected and caught, and not too late, so they have not yet abandoned the offshore grounds towards the coasts.

The survey covered the entire expected spatial distribution of juvenile anchovy in these months of the year, from offshore areas well beyond the continental shelf to very coastal waters, because the spatial process of anchovy juvenile recruitment occurs from offshore areas towards the coast during autumn (Uriarte *et al*., 2001). This exploration area can vary from year to year and is potentially large. Consequently, considerable effort was made to achieve the broadest possible coverage of the area by using an adaptive sampling strategy. In this strategy, the boundaries of the sampling area were defined according to the findings of each survey and the parallel information obtained from the commercial fishing fleet, which uses juvenile anchovy as live bait for tuna fishing. Along the Spanish and French coastlines, the minimum limits of the sampling area were set at 5°W and 46°N respectively. According to previous information on juvenile distribution, this area was expected to contain the vast majority of the juvenile anchovy abundance (Uriarte *et al*., 2001; Carrera *et al*., 2006; Cort *et al*., 1976). For practical reasons, a maximum surveying area was set within the limits 6°W and 48°N. Between these limits, the actual along-coastline boundaries were set each year at the points where there was a clear decrease in abundance or, if possible, a transect in which juvenile anchovy were not detected. The length of the transects extended from about the 20 m to at least the 1000 m isobaths, and, according to the adaptive scheme of the survey, if the detections continued they were enlarged offshore to 4 n.mi. beyond the last detection of an anchovy school. In addition, the information from the commercial live bait tuna fishery collected before and during each survey was taken into account when decisions about the sampling strategy were made during the surveys. As a result of this sampling scheme, the years with a larger abundance of anchovy required a larger sampling coverage.

In the period from 2003 to 2004, the area was sampled with a single commercial purse-seiner subcontracted for the survey and equipped with scientific echosounders. In 2005 a second purse-seiner was added to the survey to provide extra fishing operations, and in 2006 a pelagic trawler with complete acoustic equipment, the R/V Emma Bardán, replaced the second purse-seiner.

B.3.4.2 Data acquisition

The acoustic equipment included Simrad EK60 split-beam echosounders (Kongsberg Simrad AS, Kongsberg, Norway) of 38 and 120 kHz from 2003 to 2006, plus a 200 kHz transducer from 2007 (Table 2). The transducers were installed looking vertically downwards, at about 2.5 m depth, at the end of a tube attached to the side of the vessel in the case of the commercial fishing vessels and on the vessel hull in the case of the research vessel. The transducers were calibrated using standard procedures (Foote, 1987).

The water column was sampled acoustically to a depth of 200 m. Catches from the fishing hauls and echotrace characteristics were used to identify fish species and determine the population size structure. Purse-seining was used to collect samples up to 2005 and then this was combined with pelagic trawls from 2006 onwards. To improve species identification in the first three surveys when only purse-seiners were available, additional night fishing operations were performed by focusing bright light on the water to attract the fish from surrounding waters. In 2006 pelagic trawling was included in the surveys, which made it possible to fish at greater depths than the purse-seine range (50 m maximum). The purse-seiners generally covered the coastal areas and the waters off the shelf where juveniles occupy the surface waters and are accessible to the purse-seine fishing range. The pelagic trawler covered the intermediate shelf regions where it may be necessary to sample at all depth layers. In addition, when deep, anchovy like aggregations were detected by the purse-seiners, the pelagic trawler temporally left its coverage area to carry out additional fishing operations in these areas.

For the years when pelagic trawling was carried out in the surveys (2006 onwards) we have assessed the fraction of juvenile biomass observed deeper than 45 m below the surface. This assessment was restricted to the areas over the shelf because pure aggregations of juveniles off the shelf were all above 45 m depth. This was done in order to determine by how much the limited vertical fishing range of purse-seines could have affected the detection and estimates of juvenile biomass in the years 2003–2005, when only this fishing gear was available, and to eventually correct the potential underestimation of the juvenile biomass detected over the shelf in those years.

B.3.4.3 Intercalibration of acoustic data between vessels

Since the 2006 survey, when the acoustic sampling was split between two vessels, intercalibration exercises between the two vessels were routinely carried out each year based on the intercalibration methodology described by Simmonds and MacLennan (2005). The intercalibration process consisted in comparing the echo integration of the bottom echo in areas with a smoothly variable bottom (visible as overlapping transects in Figure B.3.4.1). A minimum distance of 30 n.mi. was covered simultaneously by the two vessels for these exercises (Figure B.3.4.1). The NASC values (Maclennan *et al.*, 2002) obtained by the layer echo integration of both the water column and bottom echos obtained by the two vessels were compared to detect recording biases or other potential problems.

B.3.4.4 Abundance estimates

Echograms were examined visually with the aid of the catch species composition to identify positive anchovy layers. Noise from bubbles, double echoes, and, when necessary, plankton were removed from the echograms. Acoustic data were processed in the positive strata by layer echo integration using an ESDU (Echo integration Sampling Distance Unit) of 0.1 n.mi. with the Movies+ software (Ifremer, France). Echoes were thresholded to -60 dB and integrated into six depth channels: 7.5–15 m, 15–25 m, 25–35 m, 35–45 m, 45–70 m and 70–120 m (no anchovies were found below 120 m depth).

Generally, only the 38 kHz data were echo integrated using the TS-length relationships agreed in ICES WGACEGG for the main species (ICES, 2006; Table B.3.4.1). Each fishing haul was classified into species. A random sample of each species was measured to determine the length–frequency distribution of the different species in 0.5 cm classes for the smaller species (anchovy and sardine) and one cm classes for the rest. Complete biological sampling of anchovy was performed to analyse age, size and the size–weight ratio. The hauls were grouped by strata of homogeneous species and size composition. The species and size composition of each homogeneous stratum were obtained by averaging the composition (in numbers) of the individual hauls contained in the stratum weighted to the acoustic density in the vicinity (2 n.mi. diameter). This species and size composition of each stratum was used to obtain the mixed species echo integrator conversion factor (Simmonds and Maclennan, 2005) for converting the NASC values of each ESDU into numbers of each species. However, although the methodology involved estimating multiple species, the survey strategy was focused strongly on juvenile anchovy and only the positive areas for anchovy were processed. Therefore, only estimates of this species were considered reliable and thus produced.

The procedure is as follows:

Each fish species has a different acoustic response, defined by its scattering cross section that measures the amount of the acoustic energy incident to the target that is scattered backwards. This scattering cross section depends upon specie *i* and the size of the target *j*, according to:

$$\sigma_{ij} = 10^{TS_j/10} = 10^{\{(a_i + b_i \log L_j)/10\}}$$

Here, L_j represents the size class, and the constants a_i and b_i are determined empirically for each species. For anchovy, we have used the following TS to length relationship:

$$TS_j = -72.6 + 20 \log L_j$$

The composition by size and species of each homogeneous stratum is obtained by averaging the composition of the individual hauls contained in the stratum, being the contribution of each haul weighted to the acoustic energy found in its vicinity (2 nm of diameter). Thus, given a homogeneous stratum with M hauls, if E_k is the mean acoustic energy in the vicinity of the haul k, w_i, the proportion of species i in the total capture of the stratum, is calculated as follows:

$$w_i = \sum_j w_{ij} = \sum_j \left(\frac{\sum_{k=1}^{M} \left(q_{ijk} \cdot E_k / Q_k \right)}{\sum_{k=1}^{M} E_k} \right).$$

Being q_{ijk} the quantity (in mass) of species i and length j in the haul k; and Q_k, the total quantity of any species and size in the haul k.

In order to distinguish their own contribution, anchovy juveniles and adults were separated and treated as different species. Thus, the proportion of anchovy in the hauls of each stratum (w_{ij}) was multiplied by a age-length key to separate the proportion of adults and juveniles. Then, separated w_i were obtained for each.

Inside each homogeneous stratum, we calculated a mean scattering cross section for each species, by means of the size distribution of such specie obtained in the hauls of the stratum:

$$\langle \sigma_i \rangle = \frac{\sum_j w_{ij} \sigma_{ij}}{w_i}.$$

Let s_A be the calibration-corrected, echo-integrated energy by ESDU (0.1 nautical mile). The mean energy in each homogeneous stratum, $E_m = < s_A >$, is divided in terms of the size-species composition of the haul of the stratum. Thus, the energy for each species, E_i, is calculated as:

$$E_i = \frac{w_i \langle \sigma_i \rangle E_m}{\left(\sum_i w_i \langle \sigma_i \rangle \right)}$$

Here, the term inside the parenthesis sums over all the species in the stratum. Finally, the number of individuals F_i of each species is calculated as:

$$F_i = H \cdot l \frac{E_i}{\langle \sigma_i \rangle}$$

Where l is the length of the transect or semi-transect under the influence of the stratum and H is the distance between transect (about 15 nm.). To convert the number of juveniles to biomass, the size-length ratio obtained in each stratum is applied to obtain the average weight of the juveniles in the stratum:

$$< W_i > = a \cdot < L_i >^b$$

Thus, the biomass is obtained by multiplying F_i times $< W_i >$.

Anchovy juveniles (age=0) and adults (age ≥ 1) were separated and treated as different species. To separate juveniles from adults, the length frequency distribution of anchovy by haul was multiplied by a corresponding age-length key. The key was determined every year for three broad areas: the pure juvenile area, the mixed juvenile area (with a mix of juveniles and adults), and the Garonne area (also a mixed area but here adult anchovy were usually smaller than in the other areas).

B.3.4.5 Recruitment predictive capability

The annual biomass estimates for anchovy juveniles were compared with the estimates of anchovy recruitment the following year. The recruitment is the biomass of age-1 anchovy in January of the following year, estimated according to the ICES assessment using a Bayesian model with inputs from catches and biomass estimates of two spring surveys: an acoustic one (PELGAS), conducted by Ifremer, and a survey based on DEPM (BIOMAN), conducted by AZTI (ICES, 2011). Up to 2012, The Spearman rank correlation between the JUVENA series and the assessment estimates of recruitment at age 1 is 0.81, which is statistically significant with p-value=0.01, and the Pearson correlation is 0.94, which is statistically significant with p-value=0.000163. In addition, JUVENA's juvenile abundance index shows also statistically significant (Pearson's) correlations with the series of recruit estimates provided independently by each of the spring surveys (R=0.94 P(R=0)=0.000 for DEPM and R=0.89 P(R=0)=0.001 for Acoustics). WGHANSA (2012), like Boyra *et al.* (2013), concluded that the JUVENA acoustic index of juveniles is a valid indicator of the strength of the incoming recruitment and hence useful for improving the forecast of the population and potentially its assessment.

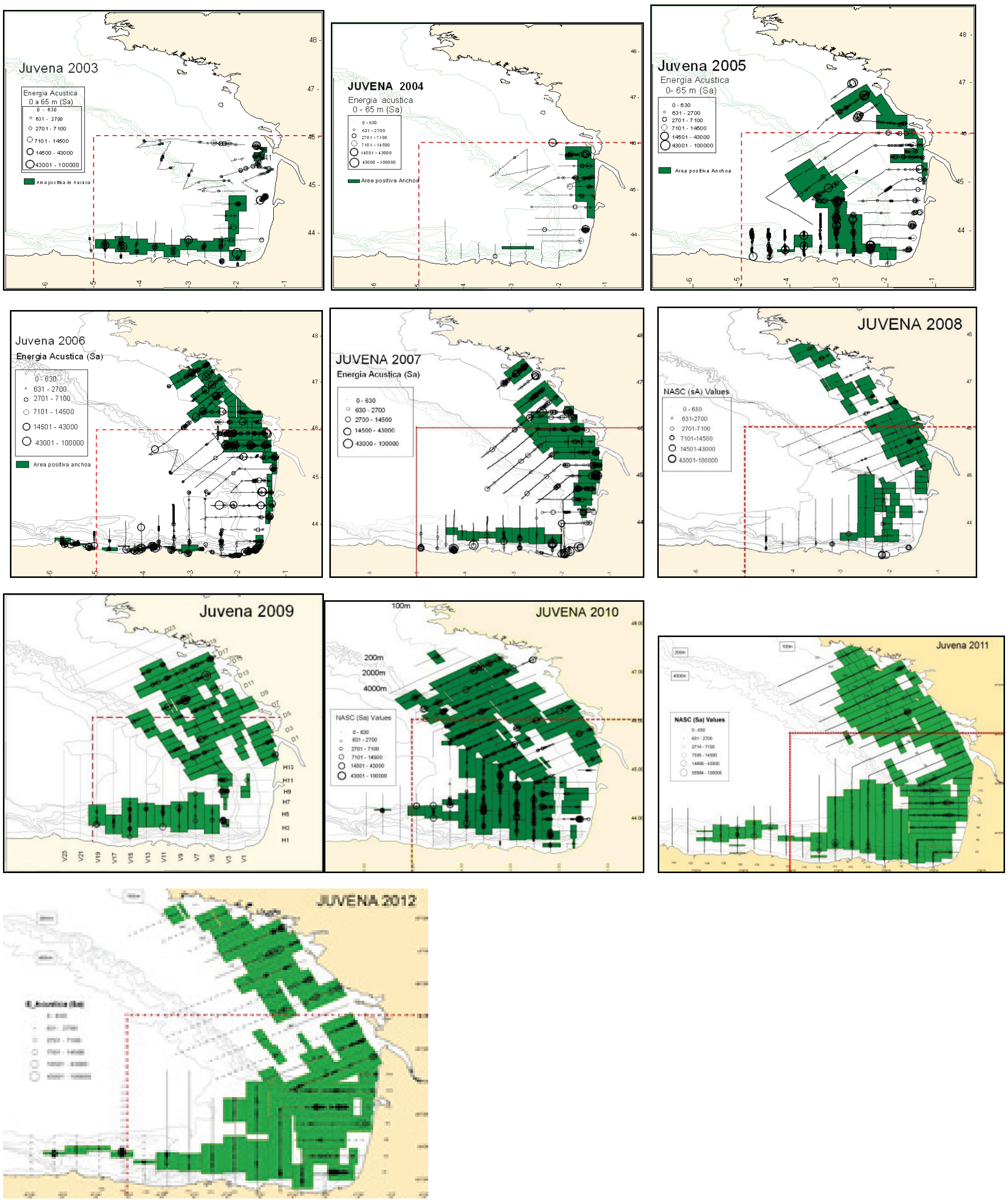


Figure B.3.4.1. Positive area of presence of anchovy and total acoustic energy echo-integrated (from all the species) for the ten years of surveys. The area delimited by the dashed line is the minimum or standard area used for inter annual comparison.

Table B.3.4.1. Vessels and equipment.

			VESSEL 1	VESSEL 2
Vessel	name		Variable*	Emma Bardán
	Length (m)		30–35	27
	Side (m)		8	7
	Draft (m)		3.5–4	3.5
	Acoustic installation		side perch	hull
Acoustic Equipment	Transducer frequencies (kHz)		38,120, (200)**	38,120,200
	Power (for 38, 120, 200 kHz) (W)		1200, 250, (210)**	1200, 250, 210
	Pulse duration (10^{-6}s)		1024	1024 (except in 2006: 256)
	Ping interval (s)		0.25–0.5	
Target Strength (b_{20})***	*Engraulis encrasicolus* *Sardina pilchardurs* *Sprattus sprattus*	-72.6 dB	Degnbol *et al.* (1985)	
	Trachurus trachurus *Trachurus mediterraneus* *Scomber japonicas*	-68.7 dB	ICES (2006)	
	Scomber scombrus	-88 dB	Clay and Castonway (1996)	
	Jellyfish (mean TS)	-81.7 dB	Average TS for jellyfish species in Simmonds and Maclennan (2005)	
Fishing gear****	Pelagic trawl	nº of doors		2
		vert opening		15
		Mesh size (mm)		4
	Purse-seine	Depth	75	
		Perimeter	400	
		Mesh size	4	

(*Vessel names: Divino Jesus de Praga (2003), Nuevo Erreñezubi (2004), Mater Bi (2005), Gure Aita Joxe (2005, 2008), Itsas Lagunak (2006, 2007, 2009, 2010, 2011, Ramón Margalef (2012)). **The 200 kHz transducer has been available onboard purse-seiners since 2007. ***TS of the mean pelagic species. The TS is obtained according to the relationship TS = b20 - 20log(L), where L is the standard length of the fish in cm. ****The fishing gear of RV Ramon Margalef in 2012 was a pelagic trawl identical to the Emma Bardan one.

B.4 Commercial cpue

According to literature, cpue indices have been considered as not reliable indicators of abundance for small pelagic fishes (Ulltang, 1980, Csirke 1988, Pitcher 1995, Mackinson *et al.* 1997). Current series of cpue available for the Spanish Purse seine are not considered of utility for the monitoring of the fishery (Uriarte *et al.*, 2008).

B.5 Other relevant data

Members of the South Western Waters Regional Advisory Council (SWWRAC) participated in the benchmark workshop process for the Bay of Biscay anchovy stock. They provided their opinion relative to the anchovy assessment (SWW RAC Opinion 69, 22 November 2012) and participated to WKPELA, their input being reflected in the report.

C. Stock assessment method

There are two points in time where an assessment can be given for this stock: in June when SSB is estimated based on the most recent spring surveys information and in December when the assessment can incorporate the most recent juvenile abundance index from JUVENA, the catches in the second semester and any other updated data. In the former the assessment goes up to June, whereas in the latter the assessment covers the whole year up to December.

C.1 June assessment

<u>Model used:</u>

The assessment for the Bay of Biscay anchovy population is a Bayesian two-stage biomass-based model (CBBM) (Ibaibarriaga *et al*., 2011), where the population dynamics are described in terms of biomass with two distinct age groups, recruits or fish aged 1 year, and fish that are 2 or more years old. The biomass changes exponentially with time according to intrinsic growth, natural mortality and fishing mortality rates. Growth and natural mortality are separated processes that are assumed constant along time but distinct across age groups (recruits and older individuals). Fishing is treated as a continuous process in time separated by semester. The first semester fishery consists mainly of the Spanish purse-seine fishery operating in spring, and the second semester fishery primarily relates to the French fleet. Furthermore, fishing mortality by semester is separable into age and year effects.

The observation equations consist of:

- log-normally distributed spawning–stock biomass from the acoustics and DEPM surveys, where the biomass observed is scaled to the true population biomass by the catchability coefficient of each of the surveys. The variance of the SSB observation equations from the surveys are split as the sum of the variances obtained from the surveys (sampling error changing from year to year and fixed according to the survey results) and the residual variance (constant parameter across years estimated from the model).
- the beta distributed age 1 biomass proportion from the acoustics and DEPM surveys, with mean given by the true age 1 biomass proportion in the population.

- log-normally distributed juvenile abundance index from the JUVENA surveys, where the abundance index observed in year (y-1) is related to the true recruitment (age 1 biomass in January of year y) by a power model:

$$\log\left(R_{\text{juv}}(y)\right) \sim \text{Normal}\left(\log\left(q_{\text{juv}}\right) + k_{\text{juv}} \log\left(R_y\right), \frac{1}{\psi_{\text{juv}}}\right),$$

  where q_{juv}, k_{juv} and ψ_{juv} are respectively the catchability, the power and the precision of the JUVENA surveys that need to be estimated.

- log-normally distributed total catch by semester.
- beta distributed age 1 biomass proportion in the catch by semester.
- normally distributed growth rates by ages.

The unknown parameters are the initial biomass, the mean and the precision of the recruitment process in log scale, the acoustic and DEPM surveys catchabilities, the catchability and the power parameters of the JUVENA index, the parameters affecting the precision of the survey and catch observation equations, the year and age components of the fishing mortality by semester, the annual intrinsic growth rates by age, the precision of the observation equations for growth and the annual natural mortality rates by age, though in the standard assessment the natural mortality will be fixed at the values agreed by the WG (see below).

Inference on the unknowns is made using Markov Chain Monte Carlo (MCMC).

Software used:

The model is implemented in BUGS (www.mrc-bsu.cam.ac.uk/bugs/). The WinBUGS development interface was used to reduce run times. The assessment is run from R (www.r-project.org) using the package R2WinBUGS.

Model Options chosen:

- Catchability of the DEPM and acoustic SSB estimates and of the juvenile abundance indices are estimated. DEPM and acoustic surveys are assumed to provide unbiased proportion of age 1 biomass estimates in the stock.
- Natural mortality rates are fixed at M_1=0.8 and M_{2+}=1.2.

The set of priors as defined in Ibaibarriaga *et al*., 2011 are used. The logarithm of the power parameter of the JUVENA index was assumed to have a normal prior distribution with median at 0 and precision 0.5. The prior distribution of the catchability parameter of the JUVENA index was considered wider than that assumed for the acoustic and DEPM surveys. A normal distribution with median at 0 and precision 0.1 was selected for the logarithm of the JUVENA index catchability. The prior distribution of the precision of the JUVENA index observation equation was the same as for the acoustic and DEPM surveys.

The length of the MCMC run, the burn-in period (removal of the first draws to avoid dependency on the initial values) and the thinning to diminish autocorrelation should be enough to ensure convergence and obtain a representative joint posterior distribution of the parameters.

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year. Yes/No
Caton	Catch in tonnes by semesters	1987–latest year	1 to 2+	Yes
Canum	Catch-at-age in numbers by semesters	1987–latest year	1 & 2+	Yes
Weca	Weight-at-age in the commercial catch by semesters	1987–latest year	1 to 2+	Yes
Mprop	Proportion of natural mortality before spawning	Not applicable		
Fprop	Proportion of fishing mortality before spawning	Not applicable		
Matprop	Proportion mature-at-age	Not applicable		
Natmor	Natural mortality M_1=0.8 and M_{2+}=1.2	1987–latest year	1 to 2+	No
G	Intrinsic growth rate	1987–latest year	1 to 2+	Yes

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	DEPM SSB spring series	1987–latest year (with gap in 1993)	
Tuning fleet 2	Acoustic SSB spring series	1989–latest year (with gaps)	
Tuning fleet 3	DEPM P1 (B1/SSB) spring series	1987–latest year (with gaps)	
Tuning fleet 4	Acoustic P1 (B1/SSB) spring series	1989–latest year (with gaps)	
Tuning fleet 5	Juvenile abundance index from JUVENA autumn survey	2003–latest year	Recruitment

Prior distributions of the parameters:

The current prior distributions (see table below) are described and justified in Ibaibarriaga *et al.* (2011) and in Ibaibarriaga and Uriarte (2013, WD to WGHANSA-ICES CM 2013/ACOM:16).

Parameter	**Hyperparameter**	**Median (90% probability interval)**
q_{surv}	$\mu_{q_{\text{surv}}} = 0 \quad \psi_{q_{\text{surv}}} = 2$	1 (0.3, 3.2)
q_{juv}	$\mu_{q_{\text{juv}}} = 0 \quad \psi_{q_{\text{juv}}} = 0.1$	1 (0.005, 181.5)
k_{juv}	$\mu_{k_{\text{juv}}} = 0 \quad \psi_{k_{\text{juv}}} = 0.5$	1 (0.098, 10.2)
ψ_{surv}	$a_{\psi_{\text{surv}}} = 0.9 \quad b_{\psi_{\text{surv}}} = 0.02$	29.8 (1.7, 139.9)
ψ_{juv}	$a_{\psi_{\text{juv}}} = 0.9 \quad b_{\psi_{\text{juv}}} = 0.02$	29.8 (1.7, 139.9)
ξ_{surv}	$\mu_{\xi_{\text{surv}}} = 5 \quad \psi_{\xi_{\text{surv}}} = 0.2$	5 (1.3, 8.7)
ξ_{catch}	$\mu_{\xi_{\text{catch}}} = 5 \quad \psi_{\xi_{\text{catch}}} = 0.2$	5 (1.3, 8.7)
B_0	$\mu_{B_0} = 10.3 \quad \psi_{B_0} = 1.0$	29 733 (5 740, 154 022)
μ_R	$\mu_{\mu_R} = 9.8 \quad \psi_{\mu_R} = 1.0$	9.8 (8.2, 11.4)
ψ_R	$a_{\psi_R} = 2 \quad b_{\psi_R} = 3$	0.6 (0.1, 1.6)
$s(\text{sem}_j, 1)$	$a_s = 0 \quad b_s = 2$	1.0 (0.1, 1.9)
$f(\text{sem}_j, y)$	$\mu_f = -0.9 \quad \psi_f = 1$	0.4 (0.1, 2.1)
G_a	$\mu_{\log(G)} = -0.7 \quad \psi_{\log(G)} = 2$	0.5 (0.2, 1.6)
ψ_G	$a_{\psi_G} = 1.5 \quad b_{\psi_G} = 0.1$	11.8 (1.8, 39.1)

Note: Sufix surv refers to either acoustic or DEPM spring surveys

C.2 December assessment:

The assessment conducted in June can be updated using the same settings in December once the results from the JUVENA survey and the catch levels during the second semester are available. The definitive DEPM estimates which are obtained after the full processing of the adult samples are completed by November and should be incorporated in this update. It must be taken into account that only preliminary estimates of the total catch in the first and the second semesters and of the age structure of the catch during the first semester of the interim year Y would be available in December.

D. Short-term projection

The forecast can be given either based on the June or on the December assessment. In June, there is no indication on next year recruitment, so the forecast is based on an assumed scenario constructed from past recruitments. In December the forecast can be based on the next year recruitment distribution derived from the December assessment (which will be informed ultimately by the JUVENA anchovy juvenile index).

D.1 June forecast:

Model used:

The CBBM model (Ibaibarriaga *et al.* 2011) used for the assessment of the stock is used to project the population one year forward from the current state and to analyse the probability of the population in the next year of being below the biological reference point B_{lim} under a recruitment scenario based on the past recruitment-series and under alternative exploitation levels for the second half of the current year and the first half of next year. Exploitation can be given either in terms of fishing mortality or in terms of catches.

The predictive distribution of recruitment at age 1 (in mass) in January next year is defined as a mixture of the past series of posterior distributions of recruitments as follows:

$$R_{2008} = \sum_{y=1987}^{2007} w_y \; p(R_y | \cdot \,) \,,$$

where $p(R_y | \cdot)$ denotes the posterior distribution of recruitment in year y and w_y are the weights of the mixture distribution, such that $\sum w_y = 1$. When no information about incoming recruitment is available all the years are equally weighted, resulting in an undetermined recruitment scenario. This is the typical situation in June.

Software used:

The projections are implemented in R (www.r-project.org), using ad hoc script for the anchovy model.

Projection period:

One year ahead from the spawning period (15th May) in the last assessment year.

Initial stock size:

Posterior distribution of SSB in the last assessment year

Maturity: NA

F and M before spawning: NA

Weight-at-age in the stock: NA

Weight-at-age in the catch: NA

Intrinsic growth rate (G):

Intrinsic growth rates are assumed distinct by age groups and their posterior distribution from the assessment is used.

Natural mortality rate (M):

Assumed constant same as in the assessment (M_1=0.8 and M_{2+}=1.2)

Exploitation pattern:

Alternative options for the year effect of fishing mortality by semester are tested. The age effects of the fishing mortality by semester are taken from the posterior distribution from the assessment.

Intermediate year assumptions: NA

Stock–recruitment model used:

No implicit S/R model is used. Recruitment is sampled from the posterior distributions of past series recruitments. The default recruitment scenario in June is the undetermined case, where all past years are equally likely. However, if there are other reliable indications available, different recruitment scenarios could be constructed by giving different weights to the past series recruitments.

Procedures used for splitting projected catches: NA

D.2 December forecast

The method for the short-term projections based on the December assessment is the same as the ones based on the June assessment, the main difference being that the next year recuitment distribution is obtained directly from the assessment. This recruitment distribution is mainly obtained by the latest JUVENA juvenile abundance index and the parameters of the JUVENA observation equations estimated from the model. Therefore, if the latest juvenile abundance index is high/low, the recruitment distribution are centered around high/low values. The December assessment provides estimates of the fishing mortality in the second semester in the interim year and the December short-term projections allow for exploring catch options for the first semester of the following year. For the current management calendar, where the TAC is set from July to June next year, the December short-term projections could be used to adjust the TAC accordingly for the first semester until a new assessment in June. At request, the December forecast can be extended for the whole year subject to a range of annual catches and the apportioning between the two halves of the year.

E. Medium-term projections

No medium-term projections are applied to this fishery for the provision of advice by ICES.

F. Long-term projections

No long-term projections are applied to this fishery for the provision of advice by ICES. Long-term projections (ten years ahead) were run by STECF in 2008 to set the basis of a management plan on anchovy to the EC. This work was based in other assessment models and assumptions. Thus, the biomass estimates obtained with the new methods are not valid to inform the harvest control rules in the draft management plan proposal of this stock. The long-term management plan proposal should be revised accordingly.

G. Biological reference points

The results of applying the CBBM according to this stock annex in June 2013 are shown in Annex 1 and they are used here as the basis for the definition of Biological reference points.

A stock–recruitment relationship is not explicitly used, given that no clear pattern arises from the scatter plot of SSB and Recruits (Figure G.1):

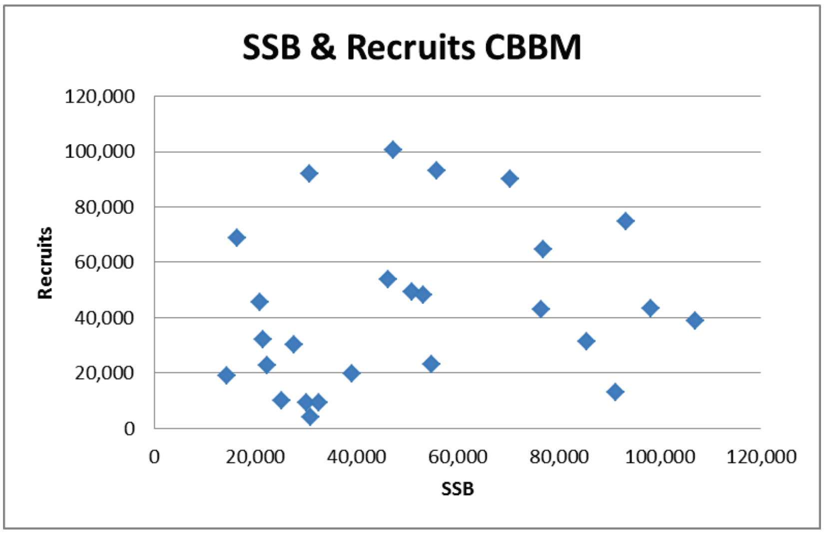


Figure G.1: Plots of Recruits vs parental Spawning Biomass (SSB) from the CBBM assessment in June 2013 see data in Annex1).

Fitting a segmented regression resulted in an inflection point at 48 362 t. (just around the historical median SSB of 46 715 t.) and was not statistically significant (P= 0.24). Such fitting would lead to admit that B_{lim} could be at the median biomass since 1987, and therefore the fishery would have been operating on a population below Blim half of the years. This is hard to believe for a fishery leading to harvest rate around 0.54 (between 1987-2004) and with more than 50% of the catches being taken after mid spawning time. So it was considered better searching for a Blim somewhere in the lower range of historical SSB values.

B_{lim} is defined as B_{loss} (minimum estimated biomass which still produced a substantial recruitment) based on the posterior median of the 1987 and 2009 SSB estimates (of 21425t and 20776 t respectively in the 2013 CBBM assessment), which are the third and fourth lowest values in the series. This results in B_{lim} at 21000 t. Notice that 2009 is the year after which a series of weak SSB abundances (since 2005 accompanying a repeated failure of the fishery and its closure) produced a significant recruitment restoring the population to medium levels. The Biomass in 1987, which was very similar to the 2005 one, did also produce a significant recruitment (close to geometric mean R). The two lowest SSB values arose in years 1989 and 2005 (assessed at 16 404 t and 14 291 t respectively) with a mean of 15 348 t. These two values were omitted when calculating B_{loss} for the following two reasons: The 2005 SSB value was the lowest in the series and correspond with the failure and closure of the fishery. The stock did not recover the next year (in 2006) and took 5 years (until 2010) to get a substantial recovery of biomasses as to reopen the fishery. The 1989 level is likely to be an underestimate in the current assessment. The 1989 SSB (at 16404 t) which was used in the former stock annex as the year of reference for definition of B_{lim}, is not considered any longer a proper reference point. The 1989 DEPM SSB input value used to be corrected upward by 1 SD in the past assessments because of presumed underestimation, However nowadays that input value is not corrected as the underestimation is considered likely but of uncertain magnitude and the former correction would be too strong. . As such, the SSB estimate may suffer some uncertain underestimate and it is preferable avoiding taking the 1989 SSB biomass as the reference value for the Blim.

This B_{lim} value (21000t) is also approximately the median of the seven lowest SSB levels in the series, (years: 1987/1989/2003/2005/2006/2008/2009), a range of SSB where low recruitments occurred more often (in 71.5%) than medium or high recruitments. This median SSB is 21435 t. Therefore, the probability of suffering impaired recruitment under these levels is presumed in accordance with the B_{lim} definition.

	TYPE	VALUE	TECHNICAL BASIS
MSY	MSY $B_{trigger}$	Not defined	
Approach	F_{MSY}	Not defined	
	B_{lim}	21 000 t	B_{loss} (median of SSB estimates in years 1987 and 2009, minimum estimated biomasses which still produced a substantial recruitment)
Precautionary	B_{pa}	Not defined	
Approach	F_{lim}	Not defined	
	F_{pa}	Not defined	

H. Other issues

None.

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Annex 1

Results of applying the June assessment in June 2013

These results were obtained after WKPELA2013 and after WGHANSA 2013 as required to close properly the stock annex and the definition of the biological reference points. It includes the latest inputs from surveys in the spring 2013.

Table A.1: Summary output of the CBBM assessment of the Bay of Biscay anchovy, following the stock annex of WKPELA but with Power catchability for the JUVENA series and Variance setting of the Spring Survey biomasses as Case 2 (Var.Estimated as in Annex 3 of WKPELA).

	Recruitment			SSB			F.sem1			F.sem1		
	5%	50%	95%	5%	50%	95%	5%	50%	95%	5%	50%	95%
1987	12,076	16,147	22,026	16,502	21,435	28,658	0.91	1.19	1.52	0.21	0.31	0.43
1988	26,357	32,209	40,135	24,311	30,034	38,405	0.76	0.98	1.23	0.23	0.31	0.41
1989	6,667	9,377	13,333	11,376	16,406	23,173	0.65	0.91	1.26	0.11	0.16	0.24
1990	59,874	68,872	80,017	47,056	54,869	64,470	0.95	1.18	1.43	0.44	0.58	0.77
1991	17,694	23,156	30,946	22,918	30,675	40,371	0.85	1.11	1.44	0.17	0.24	0.34
1992	72,403	92,042	117,008	57,908	77,009	100,542	0.83	1.11	1.48	0.19	0.29	0.43
1993	51,534	64,861	80,822	64,002	76,479	91,251	0.64	0.81	1.01	0.35	0.47	0.62
1994	35,242	43,045	53,130	41,706	50,932	62,686	0.87	1.09	1.35	0.37	0.50	0.69
1995	38,561	49,513	66,171	34,185	46,253	62,666	1.01	1.36	1.81	0.18	0.27	0.41
1996	42,617	53,637	66,836	43,263	53,167	66,407	0.83	1.08	1.39	0.37	0.52	0.72
1997	37,049	48,050	61,698	42,708	55,793	71,423	0.41	0.53	0.70	0.28	0.39	0.56
1998	71,682	92,967	120,572	76,029	98,194	125,454	0.31	0.41	0.54	0.27	0.39	0.57
1999	30,638	43,478	60,476	54,213	70,369	90,608	0.38	0.51	0.68	0.26	0.36	0.52
2000	73,865	90,219	110,194	76,534	93,280	112,433	0.56	0.70	0.89	0.24	0.33	0.44
2001	62,318	74,608	89,322	78,671	91,202	107,170	0.54	0.65	0.79	0.33	0.43	0.54
2002	9,127	13,030	18,564	31,747	39,140	49,225	0.43	0.55	0.67	0.35	0.46	0.61
2003	15,553	19,634	24,835	22,514	27,703	34,913	0.29	0.38	0.47	0.41	0.56	0.74
2004	24,588	30,333	38,561	24,414	30,871	40,026	0.64	0.84	1.09	0.36	0.52	0.72
2005	2,636	3,942	5,866	10,265	14,291	20,122	0.11	0.16	0.22	NA	NA	NA
2006	13,440	18,864	26,370	16,221	22,222	30,027	0.16	0.22	0.30	0.01	0.01	0.01
2007	16,465	22,697	30,638	24,197	32,421	42,245	0.01	0.01	0.02	NA	NA	NA
2008	6,464	9,173	13,083	19,333	25,169	32,478	NA	NA	NA	NA	NA	NA
2009	7,347	10,199	14,273	16,190	20,776	26,782	NA	NA	NA	NA	NA	NA
2010	35,596	45,707	61,084	37,423	47,177	62,060	0.31	0.41	0.52	0.11	0.16	0.23
2011	79,221	100,710	130,679	84,720	107,123	138,804	0.24	0.32	0.41	0.05	0.06	0.09
2012	28,854	38,949	52,575	66,548	85,539	111,661	0.17	0.22	0.29	0.12	0.16	0.21
2013	21,829	31,257	44,356	42,813	58,475	80,380	0.24	0.33	0.45	NA	NA	NA

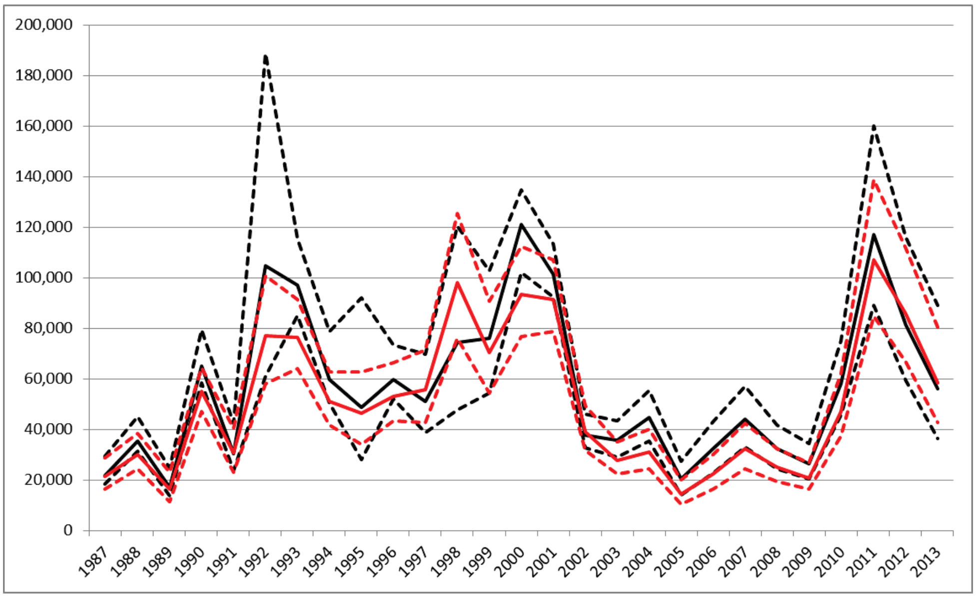

Figure A.1: Comparison of the Anchovy Spawning Biomass series from the old BBM model (from the June 2013 WGHANSA assessment- ICES 2013) (in black) and the CBBM with the new settings in the current Stock Annex (in red).